

**ACUTE EFFECTS OF SELF-PACED WALKING ON SMOKING  
WITHDRAWAL AND CRAVINGS**

By

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**MAGDALENA KATOMERI**

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**WITHDRAWAL AND CRAVINGS**

**Abstract**

High relapse rates among smokers attempting to quit have been linked with failure to cope with cigarette cravings and withdrawal symptoms. Smoking cravings and withdrawal behavior is known to be influenced by stress and exposure to smoking cues. Exercise appears to reduce cigarette cravings and withdrawal symptoms. However no study has investigated the effects of exercise on cue-elicited cravings and withdrawal symptoms, or on ad libitum smoking behavior. Aim: Four experimental studies were designed to examine the effects of exercise on smoking behavior. Initial studies focused on the effects of a single session of brisk walk on cigarette cravings and withdrawal symptom. Further research examined the effects of the walk on withdrawal symptoms and cravings and response to smoking cues and time spent on ad libitum smoking. Methods: All studies examined the effects of a short bout of brisk walking (15- 20 minutes) versus a passive control condition. For the purposes of the experiments, participants were temporarily smoking abstinent or non-abstinent. Multiple and single item measures of cravings and withdrawal, as well as different experimental designs were used in order to enhance the reliability of the findings. In Studies 2, 3, and 4 after the exercise (or the control) participants were exposed to smoking cues. In these studies after the laboratory session, ad libitum smoking was determined from the subject's cell phone text message. Results: Cigarette cravings, withdrawal symptoms and negative affect decreased rapidly during exercise and remained reduced for 20-50 minutes after exercise. This pattern was robust across the four studies, across different abstinent periods, across single and multiple measures of cravings and withdrawal symptoms, across experimental designs and across samples. Furthermore, it was shown that exercise attenuated increases in cue elicited cravings and withdrawal symptoms. Results also indicated a two- to threefold longer time to the next cigarette following exercise. Exercise produced these effects by mimicking the relaxing effects of smoking. Conclusions: Short bouts of brisk walk are recommended as an aid to managing cigarette cravings and withdrawal symptoms.

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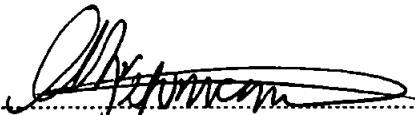
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### **Author's Declaration**

At no time during the registration for the degree of doctor of Philosophy has the author been registered for any other University award.

Relevant scientific seminars and conferences were regularly attended at which work was often presented; external institutions were visited for consultation purposes a number of papers have been published in scientific journals and several others are being prepared for publications.

Signed  .....

Date 06/04/09 .....

### **Publications**

Taylor, A.H. & Katomeri, M. (2007). Walking reduces cue-elicited cigarette cravings and withdrawal symptoms, and delays *ad libitum* smoking. *Nicotine & Tobacco Research*, 9, 1-8.

Taylor, A.H. & Katomeri, M. (2006). Effects of a brisk walk on blood pressure responses to the Stroop, a speech task, and a smoking cue among temporarily abstinent smokers. *Psychopharmacology*, 184, 147-253.

Taylor, A.H., **Katomeri, M.** & Ussher M. (2006). Effects of walking on cigarette cravings and affect in the context of Nesbitt's paradox and the circumplex model. *Journal of Sport and Exercise Psychology*, 28, 18-31.

Taylor, A.H., **Katomeri, M.** & Ussher M. (2005). Acute effects of self-paced walking on urges to smoke during temporary smoking abstinence. *Psychopharmacology*, 181, 1-7.

#### **Presentations and Conferences Attended:**

#### **Awards:**

**Third place** for the young investigator's award. FEPSAC XIth European Congress of Sport Psychology in Copenhagen. 22<sup>nd</sup>-27<sup>th</sup> July 2003.

Title: '*Effects of a single session of walking on affect and desire to smoke, during smoking deprivation.*'

**First place** for best oral presentation in sport Psychology. BASES Student Conference in Coventry. 15 –16<sup>th</sup> of April 2003

Title: '*Effects of a single session of walking on affect and desire to smoke, during smoking deprivation.*'

**NOTE: In each conference I presented different aspects of my research**

### **Conference presentations**

**Katomeri, M.** (2007). Effects of walking on urges to smoke during a smoking cue, and ad libitum smoking. *FEPSAC 12th European Congress of Sport Psychology*, abstracts, pg 172. (Oral presentation).

**Katomeri, M. & Taylor, AH** (2006). Effects of walking on desire to smoke and withdrawal symptoms during a smoking cue, and ad libitum smoking. *European College of Sport Science, 11th annual congress*, abstracts, pg231. (Oral presentation)

**Katomeri, M. & Taylor, A.H.** (2005). Effects of walking on cigarette cravings and withdrawal symptoms during smoking cue simulation. *BASES Journal of Sport Sciences*, abstracts, Pg 102. (Poster presentation)

**Taylor, A.H. & Katomeri, M.** (2005). Effects of walking on blood pressure response to smoking cues following 3 h of abstinence among smokers. *BASES. Journal of Sport Sciences*, abstracts, Pg 123.

**Katomeri, M. & Taylor, A.H.** (2005). Effects of walking on cigarettes cravings during smoking cue simulation and on the lag time to the next cigarette. *European College of Sport Science, 10th annual congress*, abstracts, pg102. (Oral presentation).

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Katomeri, M., & Taylor, A.H. (2003). Effects of a single session of walking on affect and desire to smoke, during smoking deprivation, *BASES Student Conference*. (Oral presentation awarded the best oral presentation in sport Psychology).

#### **Media coverage of research**

**Medical Research News.** “Walking can cut craving for a cigarette. New research by scientists at Exeter University has shown that going for a walk can help smokers break the habit”. Published on Sunday, 15-May-2005. Article could be retrieved from:  
[http://www.news-medical.net/print\\_article.asp?id=1003](http://www.news-medical.net/print_article.asp?id=1003)

Article by Paula Cussons. **The earth times.** “Brisk walk might help quit smoking: study. Published on Sunday, 15 May 2005 12:46:01 GMT.

Article by John Briley. **Tobacco news and information.** “Quitting Smoking”. Published on Thursday, May 5, 2005.

Article by John Briley. **The Washington Post** (Newspaper). "*Craving Cigarettes? Take a Walk*". The Washington Post (Newspaper). Article published on Tuesday, April 26, 2005;

Article by Denis Campbell (sports news correspondent). **Guardian, the observer**, (Newspaper). "*Smokers walk to fight off craving*". Article published on Sunday April 10, 2005.

Article on my research published in the Turkish Newspaper **Tüm gazeteler**. "*15 dakika yürü daha az sigara iç*" (article in Turkish). Published on Monday April 11, 2005.

**Paths to health**. "*Research suggests walking can help you quit smoking*". Article could be retrieved from: <http://www.pathsforall.org.uk/pathstohealth/article.asp?id=541>

Note: This research was also broadcasted by ITV westcountry news, BBC radio Essex, and other local radio stations.

### **Workshops attended**

- 10<sup>th</sup> - 11<sup>th</sup> Nov. 2005: Motivational Interviewing training course.
- 25<sup>th</sup> - 27<sup>th</sup> Mar. 2002: "Smoking cessation training and research programme: Setting up and running specialist smoking cessation services".
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## **Chapter 1**

### **1. Introduction**

Cigarette smoking is one of the most preventable causes of premature death (Doll, Peto, Wheatley, Gray & Sutherland, 1994). Smoking kills over 120,000 people in the UK a year, more than 13 people an hour (Callum, 1998). For the EU as a whole the number of deaths from tobacco is estimated at well over 500,000 a year (Peto, Lopez, Boreham, Thun & Heath, 1996). The government's white paper published in 1998 indicated that smoking accounted for 84% of deaths from lung cancer, and 83% from chronic obstructive lung disease, including bronchitis. In addition to lung cancer, smoking causes death by cancer of the mouth, larynx, oesophagus, bladder, kidney, stomach and pancreas. Smoking causes also one in seven deaths from heart disease. It is also linked to many other serious conditions including asthma and osteoporosis (brittle bone disease) (Peto et al., 1996).

The 1998 UK government White Paper Smoking Kills emphasises that treating illness and disease caused by smoking is estimated to cost the National Health System (NHS) up to £1.7 billion every year in G.P. visits, prescriptions, treatment and operations. Among habitual smokers there is 7% to 15% increase in out-patient visits and a 30% to 40% increase in hospital admissions and hospital days/years over time (Cohen & Barton, 1998; Curry, 2001). For reformed smokers, after four years of quitting their hospital admissions were significantly lower than those still smoking. Smoking cessation has become a national issue with serious economic implications for the NHS. The promotion of smoking cessation should be highlighted as a major benefit for the national health care cost.



## Chapter 1: Introduction

Given the implications of smoking on health, it is not surprising that the majority of smokers are thinking about quitting. Every year approximately two-thirds of all smokers report their willingness to quit to their G.P.s (McNeil, Foulds & Bates, 2001).

Unfortunately only 3% of them succeed in doing so by using will-power alone (McNeil et al., 2001). Although stopping smoking can be easy for some individuals, those with severe nicotine dependence realise that their struggle for abstinence is hard. Various treatment modalities have been proposed to help smokers quit (Hurt, Dale, Offord, Bruce, McClain & Eberman, 1992). There are pharmaceutical aids that help combat the physiological withdrawal symptoms, such as NRT (Nicotine Replacement Therapy), bupropion (zyban) and social support.

A number of studies confirmed the effectiveness of these pharmacological aids such as NRT and bupropion in increasing quit rates from 5% to 10% (Fagerstrom, 2002; Fagerström, Schneider & Lunell, 1993; Foulds, 1996; Hill, Hurt, Dale, Offord, Bruce, McClain et al., 1992; Johnson, Stevens, Hollis & Woodson, 1992; Kornitzer, Boutsen, Dramaix, Thijs & Gustavsson, 1995; Rigdon & Johnson, 1993; Tang, Law & Wald, 1994; Molyneux, Lewis, Leivers, Anderton, Antoniak, Brackenridge, et al., 2003; Perry, 2001; Raw, McNeil & West, 1998; Stead, Lancaster & Silagy, 2001; Silagy, Mant, Fowler & Lodge, 2001; Stead & Lancaster, 2002; Ussher, Taylor, West & McEwen, 2000).

Structured smoking cessation clinics have also been used with some success. These clinics provide social support and improve success rates to around 20% provided that patients use NRT or bupropion – commonly known as Zyban (West, 1997). Even with the support of the smoking cessation aids there are still smokers who are unable to stop smoking completely, whereas others succeed with occasional relapse. This gives some illustration of

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the difficulties involved in giving up nicotine and the relative ineptitude of current smoking cessation aids.

Difficulties associated with smoking cessation are often due to the side effects associated with cessation. In particular, there are psychological, physiological and psycho-social symptoms (e.g. being exposed to situations that cue smoking) that need to be overcome when one attempts to stop smoking. Some of the side effects experienced by smokers when trying to quit include nicotine cravings, and withdrawal symptoms such as difficulty in concentrating, anxiety, depressive mood, irritability and restlessness (Clavel, Benhamou & Flamant, 1987; Gritz, Berman, Marcus, Read, Kanim & Reeder, 1989; Grove, Wilkinson & Dawson, 1993; Hughes, Hatsukami, Mitchell & Dahlgren, 1986; Kawachi, Troisi, Rotnitzky, Coakley, Colditz & Colditz, 1996; King, Matarin, Marcus, Bock & Tripolone, 2000; Pirie, McBride, Hellerstedt, Jeffery, Hatsukami, Allen et al., 1992; Sayette, Martin, Wertz, Shiffman & Perrott, 2001; West, Hajek & Belcher, 1989). After just one day of quitting, at least 50% of quitters reported increased levels of depression, tension, stress, anger, lapses of concentration, anxiety, restlessness and irritability (Ward, 2001). Even after a year of quitting, some former heavy smokers complained that they were still feeling irritable compared to those who never stopped (Clavel et al., 1987). It is worth noting that in all the above studies, the frequency and intensity of these symptoms varied across individuals.

In addition to physiological side effects, smoking cessation induces withdrawal symptoms that are psychological, motivational and psychosocial in nature. For example, the urge to smoke, which is also a common withdrawal symptom associated with smoking cessation (West & Sneider, 1998), could also still be apparent a month after quitting (West, 1997).

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Therefore, for a smoking cessation program to be successful it should also be able to deal with urges to smoke. In addition, the smoker's perception that smoking has psychological benefits could also hinder the success rate of quitting (Brandon, 1996).

Cardiovascular reactivity to general stressors could also be a predictor of short-term relapse (three to six months after cessation) in smokers (Emmons, Weidner & Collins, 1989; Niaura, Abrams, Demuth, Pinto & Monti, 1989). Emmons et al., (1989) suggest that stress reactivity increases the risk of relapse through exaggeration of withdrawal discomfort or negative affect.

One possible treatment that potentially could improve cessation rates is the use of physical exercise. Evidence suggests that exercise increases positive mood and decreases the severity of many of the symptoms associated with withdrawal such as depression, tension, irritability, stress, anxiety, lack of concentration (Fox, 1999; North, McCullagh & Tran, 1990; Salmon, 2001).

There is widespread support for a positive and lasting relationship between participation in regular exercise and various indices of mood states, (e.g. consensus documents and reviews (Biddle, Fox & Boutcher, 2000; Craft & Landers, 1998). Intervention studies have also found that physical activity provides mental health benefits for persons recruited from the community who are without serious psychological problems. These benefits included upsurges in general well-being (Cramer, Nieman & Lee, 1991) and reductions in tension, confusion (Moses, Steptoe, Mathews & Edwards, 1989), perceived stress and anxiety (King, Taylor & Haskell, 1993). A number of animal studies have also shown that exercise may engage similar neuro-chemical pathways in the brain which in turn have been effective

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in reducing substance use such as amphetamine (Kanarek, Marks-Kaufman, D'Anci & Przypek, 1995), cocaine (Cosgrove, Hunter & Carroll, 2002) and ethanol (McMillan, McClure & Hardwick, 1995). A recent study has also shown that brief bouts of exercise could decrease alcohol cravings following detoxification (Ussher, Sampuran, Doshi, West & Drummond, 2004). Due to these positive effects of exercise on mood and the reduction in substance use (or cravings for the substance during abstinence) exercise could have an effect on smoking cessation by alleviating withdrawal symptoms and cravings to smoke.

It is important to realise that successful cessation of smoking maybe a function of a combination of more than one factor. The present thesis does not aim to address all psychological, physiological, and psycho-social factors but it attempts to explore ways in which negative psychological symptoms associated with smoking withdrawal can be reduced. By reducing these symptoms, smoking cessation rates may be increased. In particular, the present thesis investigates the potential of physical activity in alleviating withdrawal symptoms and urges to smoke associated with smoking cessation.

In the next chapter, issues relevant to the study of exercise psychology will first be considered, with the ultimate aim of elucidating investigation of its effects upon smoking cessation. Definitions, measurement issues, and technical terms are first to be considered, before reviewing available literature upon the relationship between exercise and affective responses, and finally discussing the findings of previous research upon the effects of exercise on smoking.

The terms exercise and physical activity are used interchangeably and refer to both lifestyle activities, such as walking, and more formal structured activities, such as stationary cycling and structured exercise in a gym

## **Chapter 2**

### **2. Literature Review**

#### **2. 1 Definitions and Measurement issues related to mood, emotion and affect in exercise psychology**

Given the evidence that exercise increases positive affect and eases the severity of severity of many of the symptoms associated with smoking withdrawal (Fox, 1999; North, McCullagh & Tran, 1990; Salmon, 2001), the purpose of the present thesis is to investigate the effects of exercise on smoking cessation. The specific research area is still at embryonic state and only a limited number of studies have been conducted in that area. Smokers are generally a sedentary population and practice an unhealthy behaviour which might contradict exercise. Therefore, before reviewing the available literature on exercise and smoking cessation it is important to investigate the effects of exercise on general affective responses. The aim of this work will be to elucidate investigation of the effects of exercise upon smoking cessation. Definitions, measurement issues, and technical terms are first to be considered, before reviewing available literature upon the relationship between exercise and affective responses, and finally discussing the findings of previous research upon the effects of exercise on smoking.

Epidemiological evidence suggests that a physically active lifestyle yields numerous health benefits (Blair, Kohl & Barlow, 1993; Blair, Kohl, Paffenbarger, Clark, Cooper & Gibbons, 1989; Powell & Blair, 1994). Evidence also indicates that physical activity is associated

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with positive mental well being (Biddle, 1995; Biddle et al., 2000; Biddle & Mutrie, 2001; Brown, 2004) and reduced reactivity to cognitive stress (Norris, Carroll & Cochrane, 1990, 1992; Stein & Boutcher, 1992).

The initial studies on the affective responses to exercise were initiated in the 1970s, and derived from the anecdotal phenomenon that exercise makes most people feel good; moreover, when people feel good, their moods and emotions seem to elevate. Emmons and Diener (1986) have shown that the amount of time individuals choose to spend in a specific situation is predicted by the affect experienced in that situation. Activities that lead to the individual feeling 'good' are more likely to facilitate future participation, while those that do not are more likely to lead to withdrawal from the activity. Therefore, maximising the affective response to exercise may be the first link in a chain between exercise and adherence (Van Landuyt, Ekkekakis, Hall, & Petruzzello, 2000).

There are several studies that have examined the effects of exercise on affective responses. Results of the studies have suggested that different intensities and durations of exercise could influence affective responses in different ways (Berger & Owen, 1988). However, the validity of much of this research received the majority of critical attention due to a number of conceptual and methodological problems related to the measurement of affect (Byrne & Byrne, 1993; Ekkekakis, Hall, & Petruzzello, 1999; Gauvin & Brawley, 1993; McAuley & Rudolph, 1995; Mutrie & Biddle, 1995; Rejeski, Hardy, & Shaw, 1991; Steptoe, 1992; Tuson & Sinyor, 1993).

## Chapter 2: Literature Review

The majority of the studies examining the psychological effects of exercise used abstract umbrella terms such as 'affect', 'mental health' and 'psychological health' or 'psychological well-being' to express the affective changes brought by exercise.

Researchers argue that the majority of the studies that examined the affective responses to exercise reported changes in distinct affective states (e.g. on depression or anxiety), without stating the nature of the effects of exercise under different conditions. To use an example provided by Ekkekakis and Petruzzello (2000), most studies examining the effects of exercise on affect focused on a single variable, such as state anxiety. However, there is no evidence that changes in state anxiety are the most salient or relevant affective changes associated with physical activity, particularly among non-anxious participants and in the absence of any anxiety-inducing stimuli. Therefore, by restricting the investigative scope to state anxiety, the effectiveness of physical activity in impacting the affective domain in general might have been obscured (Ekkekakis & Petruzzello, 2000). Furthermore, Ekkekakis and Petruzzello (2001a, 2001b) argue there is presently no evidence that there are affective states associated "unique to the exercise domain", so there is no theoretical or empirical basis for characterizing some affective states as, de facto, relevant or irrelevant to exercise. Therefore, in order to be able to prescribe exercise as an aid to promote psychological health, it is essential to define, and clarify the various constructs that fall under the affective domain and examine how they could be affected by exercise.

### 2. 1.1. Definitions of mood emotion and affect

In a series of papers Ekkekakis and Petruzzello (1999, 2000, 2002) aimed to identify and clarify the differences between moods, emotion and affect. Overall, from a broad perspective, “emotions, mood and affect could be conceptualized as lying on a continuum of evolutionary complexity with emotions requiring the most and basic affect requiring the least amount of cognitive involvement” (Ekkekakis & Petruzzello 1999, p. 356).

Emotions, according to Petruzzello and Ekkekakis, (2000) “are those affective states that are elicited following an appraisal process during which a specific object is recognized as having the potential to either promote or endanger the well being of the individual” (p 76). They are an immediate response to specific stimuli (Snyder, Harris, Anderson, Holleran, Irving, Sigmon, Yoshinobu, Gibb, Langelle & Harney, 1991; Snyder, Wallace, Moe & Liberman, 1994) and are typically characterized by a short duration and high intensity. Key to the definition of an emotion is the ability of the individual to act upon the feeling and also to appraise its usefulness. If an organism lacks the cognitive ability to make a particular appraisal then it would be able to feel the appropriate emotions. That means that “a new born may feel distressed (positive-negative appraisal) [it] cannot feel anger or sadness, which depends upon more sophisticated appraisals of agency” (Ellsworth, 1991, p. 157-158).

Conversely, moods lack a specific target, are also associated with low or no tendencies to do something about it (Fridja, 1993, 1994; Ekkekakis & Petruzzello, 2000). Moods refer to the larger pervasive existential issues of one’s life (Lazarus, 1991). In contrast to emotions, moods are not a response of a specific event but a response on how an organism views the world as a whole and its place in it at a particular point in time (Fridja, 1993, 1994; Ekkekakis & Petruzzello, 2000); to use the exact words of Ekkekakis



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and Petruzzello (2000) "To experience a mood, the organism must have some sense of the future and what it will bring" (p. 77). Conditions leading to moods typically occur slowly over time and the effect may accumulate from repeated experiences of an emotion (Buckworth & Dishman, 2002). Events evoking an emotion occur quickly, for example when individuals achieve a personal best on a fitness test they may experience a feeling of elation when they realise their achievement. If they continue to experience events that evoke positive emotions e.g. having a good workout followed by a nice meal or receiving good news, it is likely that they will experience a positive mood. The individual may even anticipate other positive things to come and mood could be sustained for another day. Moods also alter the way information is processed, which biases cognitions or thoughts (Smith and Grabbe, 2000). A sustained positive mood predisposes individuals to access positive thoughts and feelings and vice versa.

Affect has been defined as the expression of value given to a feeling state (Batson, Shaw & Oleson, 1992). It is a person's immediate, physiological response to a stimulus and it is typically based on an underlying sense of arousal (Fridja, 1999). These responses are unconscious, requiring little or no sophisticated thought and so this physical manifestation of a feeling "is present in the yelp of a dog and in the coo or cry of an infant" (Batson et al., 1992, p. 298).

After defining mood, emotion and affect, the affective domain could be conceptualized as having a hierarchical structure. "This refers to the core affect as the subjective experience that accompanies all valenced (positive or negative) responses and distinct emotions as the affective states that are elicited following patterns of cognitive appraisal" (Ekkekakis & Petruzzello, 2000, p. 36). Given the antecedents of affective responses in various

populations and under various conditions would be reasonable for research to follow a systematic progression from the general (affect) to the specific (emotions) and from the relatively simple (affect) to the complex (Ekkekakis & Petruzello, 2002). Therefore when measuring affective responses to exercise, researchers should identify how exercise could effect general affect, and then based on their findings they should concentrate on measuring specific affective states.

### **2. 1.2. Measures of mood, emotion and affect**

In the early 70s, there was a need to document the 'feel good' anecdotal phenomenon brought by exercise. It was therefore a need to use the self report measures of psychological states that were available at the time, such as the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch & Lushene, 1970) and the Profile of Mood States (POMS, McNair, Lorr & Droppleman, 1971) (Ekkekakis & Petruzzello, 1999). Due to the fact that research demonstrated positive effects with these measures they were used over the years associating the 'feel good' phenomenon brought by exercise with reductions in state anxiety and mood states tapped by the POMS and STAI. One criticism of the POMS and STAI is that they target only seven distinct states (such as tension, depression, anger, vigor, fatigue and state anxiety). Hence, they could not offer a comprehensive description of the universe of affective changes associated with exercise or the identification of the most experientially salient of these changes (Ekkekakis & Peruzzello, 2000). To use the exact words of Ekkekakis and Petruzzello (2000), although the extensive use of the POMS and STAI was accompanied by claims of 'demonstrated validity and reliability', these instruments never underwent any formal psychometric evaluation in the context of exercise. Morgan (1984) alerted researchers with these measurement shortcomings and pointed out:

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*“Much, perhaps most, of the literature dealing with the psychological effects of exercise has relied on the use of objective self report inventories designed to measure constructs such as anxiety and depression. The extent to which these inventories can tap the psychometric domain of significance to the exerciser has not been evaluated. In other words, an investigator may employ an objective, reliable, valid test of anxiety or depression to quantify the psychological effects of exercise only to find that no “effects” have taken place when in fact, there may have been numerous effects. Sport (and exercise) psychologists have debated for years about the “best” or “appropriate” psychological test to employ. The answer is actually rather simple. The measure to be employed in a particular investigation should be based upon the question being asked”.*

(Morgan, 1984, p.134).

Despite of Morgan’s recommendations, there is still a vast literature that reports the effects of exercise in various sets of distinct affective states with the use of STAI and the POMS. This is evident even in cases in which the research interest was not specifically on state anxiety and mood states, but rather on the affective responses to exercise in general. This practice has been based on the fact that these measures have been used extensively in previous research.

Other measures of affect include the Positive and Negative Affect Schedule (PANAS) (Watson, Clark & Tellegen, 1988). The PANAS does not assess distinct affective states such as anxiety and depression, but rather broad affective dimensions and gained the frequency of use across specialties in psychology and allied disciplines. The PANAS consists of ten positive mood scales (interested, excited, strong, enthusiastic, proud, alert,

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inspired, determined, attentive, and active) and ten negative mood scales (distressed, upset, guilty, scared, hostile, irritable, ashamed, nervous, jittery, and afraid) (Ekkekakis & Petruzzello, 2001b). One criticism for using the PANAS is that it only assesses the high activation poles of the theoretical negative and positive dimension, in essence providing operationalisation of only one half of the affective space (Ekkekakis & Petruzzello, 2001b).

The development of exercise-specific measures of affective states, such as the exercise induced Feeling inventory (EFI; Gauvin & Rejeski, 1993) and the Subjective Exercise Experience Scale (SEES; McAuley & Courneya, 1994) has also been criticized on several grounds (Ekkekakis & Petruzzello, 2000, 2001a, 2001b).

The EFI was based on the fundamental assumption that the stimulus properties of physical activity are capable of producing several distinct feeling states. Specifically, the EFI includes scales for the assessment of revitalization, tranquility, positive engagement and physical exhaustion (Ekkekakis & Petruzzello, 1999). On the other hand, the SEES was developed as a measure of the more general structural aspects of exercise-associated affect, compared with the EFI (Ekkekakis & Petruzzello, 2001).

The concerns that have been expressed include the imprecise description and differentiation of the content domains of exercise-induced feelings and subjective exercise experiences, the potential lack of generalisability across different populations and exercise experiences, and the non-incorporation of relevant experience on the structure of affect from general affective psychology (Ekkekakis & Petruzzello, 2001b). According to Ekkekakis and Petruzzello, (2001b) there is presently no evidence that there are affective states associated “unique to the exercise domain” so there is no theoretical or empirical basis for characterizing some affective states as de facto relevant or irrelevant to exercise.

As a possible avenue to a resolution of the emerging debate, several authors have suggested turning to conceptual models that have strong underpinnings in affective psychology. One of these models is the circumplex model of affect (Biddle, 2000; Biddle & Mutrie, 2001; Ekkekakis, 2003; Ekkekakis & Petruzzello, 2002). In the circumplex model the affective space is defined in terms of two dimensions namely affective valence (also termed *pleasure–displeasure* or *hedonic tone*) and perceived activation (also termed *arousal*). These two dimensions, theorised to be bipolar and orthogonal, form the basis of the circumplex model (Ekkekakis & Petruzzello, 2002). Hardy and Rejeski's (1989) single-item Feeling Scale (FS) has been used to assess the affective valence dimension, and Svebak and Murgatroyd's (1985) single-item Felt Arousal Scale (FAS) to assess the activation dimension (Ekkekakis, 2003; Van Landuyt et al., 2000).

Different affective states are considered combinations of varying degrees of these two constituent dimensions, such that affective states can be conceptualized as located around the perimeter of a circle defined by the two dimensions (Ekkekakis & Petruzzello, 2000). An advantage of using the circumplex is that it can disentangle changes in activation from changes in affective valence (Ekkekakis & Petruzzello, 2002). Failing to distinguish changes along the activation dimension from changes along the valence dimension may lead to misleading findings (Ekkekakis & Petruzzello, 2000). This is a problem that has been shown to be especially pronounced in studies that utilised unidimensional measures of state anxiety, such as the State-Trait Anxiety Inventory (STAI) (Ekkekakis & Petruzzello, 2000). To use the exact words of Ekkekakis and Petruzzello (2000), such measures do not allow for positively laden increases in activation or for negatively laden decreases in activation. Instead, all increases in activation are assumed to be negative (i.e., associated

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with increases in state anxiety) and all decreases in activation are assumed to be positive (i.e., associated with decreases in state anxiety or increases in calmness). However, in the context of exercise, high activation may be experienced as positive (e.g., vigor and exhilaration) or negative (e.g., tense, effort). Likewise, low activation may be experienced as positive (e.g., calmness and relaxation) or negative (e.g., exhaustion or boredom) (Ekkekakis & Petruzzello, 2002, p 44). Based on the assumption that activation and valence are *independent* constituents of affect, the circumplex model allows for measuring these variants of affective experience, thus reducing the likelihood of misleading findings (Ekkekakis & Petruzzello, 1999).

In the circumplex model, experientially similar affective states (e.g., *happy* and *glad*) are closer together on the circle, whereas affective states perceived as antithetical (e.g., *happy* and *sad*), are opposite on the circle (180° apart) (Ekkekakis & Petruzzello, 1999). Divisions of the circumplex into halves differentiate between pleasant and unpleasant states or between states characterized by high and low activation. A division of the circumplex space into quadrants produces four meaningful variants of affective experience:

1. high-activation pleasant affect, which corresponds to an energy or excitement-like state
  2. high-activation unpleasant affect, corresponding to tension and distress
  3. low-activation unpleasant affect, characteristic of fatigue, boredom and depression
  4. low-activation pleasant affect, a combination characteristic of calmness and relaxation
- (Ekkekakis & Petruzzello, 2002)

The extent of its scope comes at the expense of some specificity but it is making it possible to detect salient affective changes in response to a variety of exercise stimuli without

advanced knowledge of the exact nature or direction of these changes (Ekkekakis & Petruzzello, 2000). For example if pretest scores and posttest scores, both for the exercise group and the placebo group, are taken directly on measures of pleasure–displeasure and arousal–sleepiness and plotted in the circumplex space, it should display the basic mood-altering effect of exercise. Once the general affective responses to exercise would be established, researchers should then begin to sort out effects due to setting, cognitive set, prior mood, and so on, particularly if they interact with exercise (Russell, 1989, p.100–101).

### **2. 2 Effects of physical activity on mood, emotion and affect**

There have been many studies investigating the relationship between physical activity and mood (defined here as depression and anxiety) and affect. Physical activity involves both acute and chronic effects on mood and affect. Acute effects are assessed in the terms of state responses to a single bout of exercise or physical activity while chronic effects are effects accumulated over multiple sessions of physical activity.

The relationship between exercise and mood has been examined by many researchers (Byrne & Byrne, 1993; Martinsen & Stephens, 1994; Calfas & Taylor, 1994; Crews & Landers, 1987; DiLorenzo, Bargman, Stucky-Ropp, Brassington, Frensch & LaFontaine, 1999; Folkins & Sime, 1981; North et al., 1990; McDonnald & Hodgson, 1991; Fox, 1999; Gauvin & Spence, 1996; Scully, Kremer, Meade, Graham & Dudgeon, 1998; Lawlor & Hopker, 2001; Long & Van Stavel, 1995; Mutrie, 2000; Petruzzello, Landers & Hatfield, 1991; Landers & Petruzzello, 1994; Salmon, 2001; Taylor, 2000). This interest appears to have been stimulated initially by the reported feelings of euphoria associated with exercise.

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Exercise has been shown to improve mood by alleviating depressive mood and anxiety symptoms for many healthy individuals, (Lawlor & Hopker, 2001; North et al., 1990; Plante & Robin, 1990), as well as in clinical populations (Martinsen, 1987; Mutrie, 2000; North et al., 1990), and producing positive changes in affective responses (Martinsen, 1990; North et al., 1990). In addition, the mood effects produced by exercise occur irrespective of its mode and intensity, participant's gender and age, and regardless measures used to assess mood (Barbour & Blumenthal, 2005; Calfas & Taylor, 1994; Crews & Landers, 1987; Hugler et al., 1994; Landers & Petruzzello, 1994; Long & Van Stavel, 1995; McDonald & Hodgson, 1991; Morgan, 1994; North et al., 1990; Petruzzello et al., 1991; Taylor, 2000).

When the effects of exercise on depressive mood and anxiety were compared with other well-established interventions, such as relaxation techniques, group therapy, individual therapy and occupational therapy, the results suggested that aerobic exercise was equally effective. One of the benefits for using exercise over other interventions is the cost effectiveness of exercise (Craft & Landers, 1998; Martinsen, 1994; Martinsen, 1986; Mutrie, 2000). The effects of exercise on depressive mood may be due to physiological and biochemical changes and/or due to changes in the social factors associated with regular exercise. For example, increase in social interaction, weight loss, participation in outdoor recreation may all contribute to mood improvement (North et al., 1990). Moreover, the sense of satisfaction that is experienced when difficult physical and psychological challenges are achieved also adds to general euphoria.

In a review of the literature, Lawlor and Hopker (2001) found that exercise produced a large reduction in depressive mood (effect size: Cohen's  $d = 1.1$ ) compared with no treatment. However, many of the studies in this review were of poor quality (inadequate



randomization and lack of blinding in the outcome assessment), had brief follow-ups and sampled no clinical volunteers. These methodological weaknesses could have inflated the effect size, biasing the intervention by 20% to 40% (Schulz, Chalmers, Hayes & Altman, 1995). Thus, Lawlor and Hopker (2001) concluded that the effectiveness of exercise on depressive mood is undetermined. Mutrie (2002) challenged this by arguing that the large effect size recorded by Lawlor and Hopker offers compelling evidence for the benefits of exercise and, as Mutrie points out, unlike drug therapy, exercise has few negative side-effects.

A review of the research targeting children and adolescents suggested that evidence related to the effects of exercise to mood is inconclusive (Larun, Nordheim, Ekeland, Hagen & Heian, 2008). This is probably due to a number of factors including the small number of studies in the review, the clinical diversity of participants, types of interventions and methods of measurement.

Contrary to the widely accepted belief that physical activity has beneficial effects on depressive mood, Geddes, Butler and Hatcher (2003) argued that exercise has a limited effectiveness in the alleviation of depressive mood. This view is at odds with the National Quality Assurance Framework for Exercise (NQAfE; Department of Health, 2001), which supports the view that exercise has causal impact on mental health problems such as depressive mood. It also conflicts with the National Consensus statements on exercise and mental health published by the Health Education Authority that claims exercise is closely associated with positive affect, mood and psychological well-being.

In addition to the studies examining the effects of exercise on specific mood states, a number of studies have examined the effects of exercise on general affect (e.g., Hansen, Stevens, & Coast, 2001; Parfitt, Markland & Holmes, 1994; Steptoe & Cox, 1988; Szabo, Mesko, Caputo & Gill, 1998). Research generally supports the hypothesis that physical activity can have an acute, as well as a chronic effect on positive affect (e.g. Landers & Petruzzello, 2001; Pertuzzello et al., 1991). Acute exercise, in particular, is conducive to general well-being and eases the negative affect which is accumulated from the pressures of everyday life. Moreover, exercise helps to overcome some ill effects resultant from a sedentary lifestyle. There is no clear evidence from the existing literature of an optimal effect of exercise on mood, but this might be because the duration and intensity of exercise has varied considerably in each study (Dunn, Triverdi & O'Neal, 2001; Katula, Blissmer & McAuley, 1999; Parfitt, Eston & Connolly, 1996; Parfitt et al., 1994; Plante & Robin, 1990; Steptoe & Bolton, 1988; Steptoe, & Cox, 1988; Van Landuyt et al., 2000; Sexton, Mære & Dahl, 1989; Veale, Le Fevre, Pantelis, de Souza, Mann & Sargeant, 1992). Given the beneficial effects of an active lifestyle, it seems important to examine whether the effects of acute exercise are "dose dependent" (depended on mode, intensity and mode of exercise) and to identify the threshold of exercise that yields more beneficial effects.

### **2. 2.1. Effects of different durations and intensities of exercise on affective responses**

#### ***2. 2.1. (a) Intensity and duration of exercise***

Research has shown that high intensity exercise is associated with decrements in negative affective state (tension/anxiety), especially in unfit or sedentary individuals (Steptoe & Bolton, 1988; Tuson, Sinyor & Pelletier, 1995). Lower intensity exercise has been associated with increments in positive affective state (vigour and exhilaration), regardless

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of the activity level of individuals (Dunn , Triverdi & O'Neal, 2001; Katula, Blissmer & McAuley, 1999; Parfitt, Eston & Connolly, 1996; Parfitt et al., 1994; Plante & Robin, 1990; Steptoe & Bolton, 1988; Steptoe, & Cox, 1988; Van Landuyt et al., 2000; Sexton, Mære & Dahl, 1989; Veale, Le Fevre , Pantelis, de Souza, Mann & Sargeant, 1992).

Some researchers (Berger, 1994, 1996; Berger & Motl, 2000; Dishman, 1986) hold a consensus about the optimal threshold of exercise. Berger and Motl (2000) cited evidence for both acute and chronic mood enhancement following exercise, and identified several factors maximizing mood-enhancing effects. These factors included duration of twenty to thirty minutes at a moderate intensity, regular frequency (three times a week) that involves rhythmic breathing, predictable and repetitive movements, and an absence of interpersonal competition.

Berger and Motl's (2000) proposal that moderate exercise, lasting for at least twenty minutes, is associated with greater mood enhancement was based on the balance of evidence (i.e., more studies supported this proposal than refuted it). Ekkekakis and Petruzzello (1999) argue that this conclusion appears to be based on few published studies, that have reported negative psychological consequences after exercise sessions of high intensity or long duration (e.g. Berger & Owen, 1988, 1992; Hassmen & Blomstrand, 1991).

In their review, Ekkekakis and Petruzzello (1999) located 31 relevant research studies of which 26 examined the effects of acute aerobic exercise on affect at different workloads. The majority (56%) of these studies did not find a dose response relationship. The few studies that did find different affective responses at different exercise workloads showed

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that differences existed in specific measures only, such as physical fatigue, exhaustion, or state anxiety. These relatively minimal differences were often related to the training or fitness level of the participants. For example, Petruzzello et al. (1991) found no differences in effect sizes between studies using short and long exercise duration protocols. Specifically, they reported no differences between exercise bouts of twenty to thirty minute duration (effect size: Cohen's  $d = .75$ ) and exercise of less than twenty minutes (effect size:  $d = .78$ ). Similarly, Petruzzello and Landers (1994) examined the effects of treadmill running at 75% maximal oxygen uptake ( $VO_2\text{max}$ ) for short (fifteen minutes) and longer durations (thirty minutes) upon state anxiety and affect scores. The results indicated that state anxiety was reduced equally for both durations of exercise, while negative affect was reduced after thirty minutes of running.

Daley and Welch (2004) compared the effects of the standard health recommended exercise duration of thirty minutes with a shorter fifteen minute bout of exercise upon individuals' affect scores. The results were not statistically different between the two exercise bouts, suggesting that positive affective responses are also experienced by exercisers after relatively short bouts of acute exercise. Furthermore, Thayer et al (1993) have also shown that four to ten minutes of moderate intensity walking can be effective in reducing self-reported tension and increasing perceived energy. Similarly, in a series of studies, Ekkekakis et al. (2000) demonstrated acute effects of walking (ten to fifteen minutes walks at 15-22% HRR (Heart Rate Reserve) with positive changes in affective activation and valence occurring during exercise, but then returning to a low activation pleasant state after ten minutes post exercise. This pattern was consistent in all the self-reported measures, in different settings (outdoors and in the laboratory), during the course of two different days, and in four samples (Ekkekakis et al. 2000). The strength of this study is that short walks at

15% to 22% of HRR, which is labelled as low intensity exercise by the American College of Sports Medicine (ACSM; Franklin, 2000), makes physical activity a more realistic exercise for sedentary individuals, in comparison to the twenty to thirty minutes of vigorous or moderate exercise three to five times a week that is recommended. Therefore, contrary to the assertions of Berger, (1994, 1996), Berger and Motl (2000), and Dishman (1986), studies have indicated that there is not a dose/response relationship between exercise and affective responses.

### ***2. 2.1. (b) Self-Selection and Choice***

There is research that supports the notion that self-selected intensity exercise could have greater effects on psychological well-being. Specifically, Biddle, (2000) believes that “people will ‘feel good’ after exercise they prefer, and feel ‘less good’ after exercise that is not to their liking”. Biddle’s conclusion is based on Deci and Ryan’s self-determination theory (1985), “that one’s choice over one’s actions will encourage an internal locus of causality, enhancing, it is believed, intrinsic motivation and liking for the behaviour”. According to Csikszentmihalyi’s (1990) flow theory, participants are likely to match their personal competencies with the challenge of the task and in doing so they maximize their potential for positive outcomes. Given the above explanations, it may come as a surprise that only a few empirical studies have investigated the impact of choice of exercise intensity upon psychological responses. From a health perspective, this is important because if those factors that foster more positive affect could be identified then exercise participation may be improved.

In their review, Ekkekakis and Petruzzello (1999) identified only two published studies examining the affective benefits of self-selected exercise intensity. The first study by

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Farrell, Gustafson, and Morgan et al. (1982) studied mood in only six well-trained athletes, who ran on a treadmill under three different settings for thirty minutes, one at a self-selected pace, another at 60% VO<sub>2</sub> max, and one at 80% VO<sub>2</sub>max. The results showed that affect or mood states measured from the profile of mood states (POMS) inventory (Lorr et al., 1971) in the three conditions were not significantly different. In the second study, Zervas, Ekkekakis, Emmanuel, Psychoudaki, Psychoudaki and Kakkos (1993), tested the mood states of female participants after thirty minutes of aerobics performed at self-selected intensity, and at 40%, 60% and 80% HR max (maximal heart rate). Results showed that the highest level of exercise enjoyment was reported by the participants who self-selected their exercise workload.

Furthermore, Parfitt, Rose and Markland (2000) compared the effects of twenty minutes of treadmill exercise at a prescribed intensity exercise (65% VO<sub>2</sub>max), and a preferred intensity exercise on psychological affect and exercise enjoyment in aerobically fit individuals. Results of their study indicated that there was no difference in psychological affect or enjoyment between the two exercise sessions, although work rate was higher in the preferred condition. These results suggest that allowing fit individuals to select their own exercise intensity may be more beneficial physiologically and psychologically.

In support to the finding of the above studies that examine the effects of exercise on active participants, a number of studies reported beneficial effects of the preferred exercise intensity in sedentary individuals. A study by Parfitt et al. (2006) explored the impact of an above-lactate, below-lactate, and self-selected exercise condition on acute affective responses in sedentary individuals. Their findings support the use of self-selected intensity with sedentary individuals to promote positive affective responses. Furthermore, Ekkekakis and Lind (2006) examined the effects on sixteen overweight females and nine of normal

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weight from two twenty minute sessions of treadmill exercise. One session involved exercise at a self-selected intensity, the other session involved exercise at an imposed speed, 10% higher than the self-selected intensity chosen at the first session. The results revealed that the overweight women in the latter group experienced a significant decline in pleasure. This finding is important because it suggests that forced exercise intensity diminishes the level of enjoyment derived from exercise and the intrinsic motivation for physical activity. Exercise intensity, exercise experiences (pleasure, or lack of) and perceived exertion are all factors influencing physical activity participation (Ekkekakis & Lind, 2006). For overweight and sedentary individuals, their relative level of intensity would of course be greater than that of those who are active: the experience of exercise for those exercising at a higher level of intensity is less pleasant and more laborious, and so their adherence to exercise would be undermined.

In support to these findings Lind, Joens-Matre and Ekkekakis (2005) conducted a study where previously sedentary middle-aged individuals were asked to self-select their own workload. Results of the study indicated that formerly sedentary individuals selected an intensity that is considered physiologically effective, and reported that it did not feel hard or unpleasant. Therefore, exercise recommendations for overweight or sedentary adults should take into account not only what is safe and effective from a physiological standpoint, but also what is tolerable and enjoyable from a psychological perspective. This should also be taken into consideration when prescribing exercise for sedentary individuals who may practice unhealthy behaviours, such as smoking, that may act as a barrier to exercise. The present thesis seeks to maximise the potential effects of exercise on abstinent smokers through allowing a degree of self-pacing in their exercise task.

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To recapacitulate, exercise of low intensity, whether self-selected or imposed, has been shown to have positive effect on affective responses during the activity (Bixby, Spalding & Hatfield, 2001; Ekkekakis et al., 2000). As the intensity of exercise increases, approaching the participant's functional levels, there is a gradual decline in reported affective valence (Acevedo, Rinehart & Kramer, 1994; Bixby et al., 2001; Hall, Ekkekakis & Petruzzello, 2002; Ekkekakis & Petruzzello, 2002; Hardy & Rejeski, 1989; Parfitt & Eston, 1995; Parfitt et al., 1996; Parfitt et al., 1994). Moreover, in studies involving low-intensity exercise, and among those individuals who experience positive affective changes during such exercise, there is an extension of the positive changes that occurred during exercise into exercise recovery. This may be reflected as an affective state that is significantly improved compared to baseline, but not significantly different from that during exercise (Van Landuyt et al., 2000) or a further, typically small, improvement compared to the during-exercise assessment (Ekkekakis et al., 1999; Ekkekakis et al., 2000).

Importantly, the post-exercise positive state appears to be dynamic, involving a persistent improvement in affective valence, but two distinct phases with respect to the patterns of perceived activation: (1) a relatively short-lived period of increased activation compared to baseline and previous in-task assessments, (2) a longer period of increased activation compared to baseline, and previous in-task assessments, that gradually decrease as stretches into recovery (Ekkekakis & Petruzzello, 2000). As a result, as recovery begins, perceptions of energy gradually decrease whereas perception of calmness gradually increases (Ekkekakis et al., 2000; Tate & Petruzzello, 1995; Van Landuyt et al., 2000). There is also a robust improvement in affect, documented through a variety of measures, immediately following exercise that induced negative response during the bout (Acevedo, Gill, Goldfarb & Boyer, 1996; Bixby et al., 2001; Hall et al., 2002; Parfitt et al., 1994).



In an attempt to identify the duration of the affective responses brought by exercise, Reed, Berg, Latin, and La Voice (1998) claimed that positive affective responses can be maintained twenty minutes after exercise. However some other studies showed that affective changes can be maintained for up to thirty minutes (Steptoe, Kearsley & Walters, 1993), sixty minutes (Cox, Thomas & Davis, 2001), two hours (Daley & Welch, 2004), or even two to three hours (Petrusello & Landers, 1994) after exercise. It is still unclear which mode and duration of exercise produces the longer lasting effects on mood. Therefore, further research is needed to clarify the optimal threshold of exercise which brings greater effects on mood and affect, and longer periods of duration for these effects. Identifying the threshold of exercise which yields the greater and longer effects on affect is also very important in the study of exercise in smoking cessation. According to Emmons et al., (1989) people smoke in order to deal with negative affect. Therefore, knowledge of the duration of exercise effects may have important implications for the clinical utility of exercise in smoking cessation.

### **2. 3 Plausible Mechanisms explaining the effects of exercise on mental health improvement**

There are several views about the mechanisms explaining the beneficial effects of exercise on mood and positive affect. Exercise can be seen as having many psychological functions: distracting people from stressful events, aid psychological well-being, and stimulate positive bio-physiological and biochemical changes.

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Studies by Bahrke and Morgan (1987), and Wilson, Morley and Bird (1981), have showed that by giving psychologically-stressed participants an exercise to perform, it distracted them from their own thoughts of stress. This is known as the “distractive effect”. When compared with other activities of distraction, such as relaxation, assertiveness training, health education, and social contact, the effects of exercise proved to be as beneficial and in many cases more effective (Doyne, Ossip-Klein, Bowman & Osborn, 1983; Klein, Greist, Gurman & Neimeyer, 1985 ; McNeil , LeBlanc & Joyner, 1991; Singh, Clements & Fiatarone Singh, 2001). The exact mechanism behind this reduction in negative mood during and after exercise is unclear and warrants further investigation.

Another way in which exercise can have a beneficial effect on mood is through perceptions of self-worth and esteem. Changing body appearance through exercise may contribute to positive self-esteem and self-efficacy (Fox, 1999). Other factors contributing to elevated mood may be the social interaction that accompanies activities involving exercise (North et al., 1990). However, if the effects of exercise were the result of a simple act of social interaction then playing chess or darts could be just as effective as exercise. The underlying cause of elevated mood during and after exercise is unlikely to be a function of one factor, but instead a combination of factors that interact with each other to produce the positive results.

Two bio-physiological mechanisms explaining the beneficial effects of exercise are as follows: (i) thermogenesis or increased body core temperature through acute exercise has been suggested as a trigger for increased relaxation, similar to the effect of having a warm bath (Raglin & Morgan, 1985). (ii) The Opponents Process Model also suggests that

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exercise stimulates activity in the sympathetic nervous system (SNS). This means that adrenaline levels are increased which have an arousing effect. When the SNS is activated, it provides a catalyst for parasympathetic nervous system (PNS) activity, resulting in acetylcholine release, which has a calming effect (Solomon, 1980).

Exercise can also cause biochemical changes in the brain. The feeling of euphoria or “runners high” experienced by many exercisers is caused by the release of endorphins and activation of a ‘reward pathway’ (Fox, 1999). Endorphins are peptides, similar to opiates (e.g. morphine), which connect onto receptors in the brain and they can be described as natural pain-killers. However, like morphine, nicotine and other opiates, the body can develop an addiction to endorphins (Fox, 1999; Griffiths, 1997). Research has focused on the interaction between physical activity and central serotonin (5-hydroxytryptamine [5-HT]) as a mood enhancer (Fox, 1999). Animal and human studies have shown increases in brain 5-HT synthesis and metabolism with acute exercise, but the extent to which this mechanism is a trigger for improved mood remains unknown. Given the fact that many anti-depressant medications also work by increasing the levels of these neurotransmitters in the brain, it seems reasonable to assume that endorphins are responsible for the feelings of euphoria that are associated with exercise.

### **2. 4 Why use exercise as an aid to smoking cessation?**

Both laboratory and naturalistic studies have revealed that many individuals smoke in response to environmental stress (Epstein & Perkins, 1988; Shiffman, 1982). For example, 25% of women aged between 15 and 24 claimed that they smoked as a means of coping with general life stresses (Glassman, Covey, Stetner & Rivelli, 1990). Studies have shown

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that people are more likely to smoke in order to moderate mood and anxiety and to cope with negative affect (Abrams, 1986; Abrams, Borrelli, Shadel, King & Bock, 1987; Craig, Parrott & Coomber, 1992; Hatsukami, Nelson & Jensen, 1991). As in the cases of stress and anxiety, the effects of nicotine on mood are inhibitory, (i.e. people smoke in order to alleviate the symptoms such as stress and anxiety) and exhibitory, as with depression and boredom, (i.e. people smoke in order to cope with depression and boredom) (Marcus et al., 1993). People are more likely to smoke to reduce negative affect and mood (Brandon, 1994; Ikard & Thomkins, 1973), with many falling into relapse because of lower self-efficacy and inability to cope with negative affect (Glassman et al., 1990; Swan, Ward & Jack, 1996).

The effects on nicotine on mood may be moderated by physiological factors such as nicotine metabolism (Pomerleau & Pomerleau, 1991). Research into substance cravings has also shown that the dopaminergic mesolimbic system known as 'the reward pathway' changes in response to acute and chronic effects of drugs resulting in feelings of euphoria. This feeling of euphoria or "runners high" is also experienced by many exercisers, and is caused by the same mechanism known as 'the reward pathway' (Fox, 1999). As a result, smoking cessation treatments (e.g. bupropion, an antidepressant) have been developed to target the pleasure and reward pathways in the mesolimbic system and nucleus accumbens (Hurt, 1999).

Exercise on rodents (particularly self-paced wheel running) has been shown to arouse this 'reward pathway' and to compete successfully with addictive substances including amphetamine (Kanarek, Marks-Kaufman, D'Anci & Przypek, 1995), cocaine (Cosgrove, Hunter & Carroll, 2002) and ethanol (McMillan, McClure & Hardwick, 1995). Given that exercise has been found to have a positive influence on affect in humans (Ekkekakis, 2003; Ekkekakis & Petruzzello, 2000; Ekkekakis et al., 2000; Morgan, 1997; Taylor, 2000), it is

reasonable to propose that due to its affective influences exercise does provide effective competition against smoking cravings in humans.

A study conducted by Ussher, Sampuran, Doshi, West and Drummond (2004) has shown that following detoxification a brief bout of exercise can result in reductions in alcohol cravings. Other studies on abstaining drug users, deploying quasi-experimental designs (e.g. Palmer, Vacc & Epstein, 1988; Preedy & Peters, 1990) showed significant reductions in trait anxiety and depression during exercise. Further, Sinyor, Brown, Rostant and Seragian (1982) found that people with alcohol problems who undertook aerobic exercise were better able to cope with life-stresses after their discharge from the alcohol treatment programme. Overall, the evidence suggests that it is worth exploring the effects of exercise on smoking cessation and smoking related withdrawal.

### **2. 5 Evaluating the effects of exercise on smoking cessation**

There are six published reviews in the area of exercise and smoking cessation which provide evidence of the efficacy of exercise in promoting smoking cessation (Marcus, Albrecht, Niaura, Taylor, Simkin, Feder, Abrams & Thompson, 1995; Nishi, Jenicek & Tatara, 1997; Ussher, Taylor, West & McEwen, 2000; Taylor & Ussher, 2005; Taylor, Ussher & Faulkner, 2007; Ussher, 2005).

Marcus et al. (1995) reviewed five studies investigating the utility of exercise as a smoking relapse prevention strategy. The review did not provide sufficient evidence for the incremental effects of exercise on smoking cessation due to their very low statistical power.

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The authors concluded that future research was needed in order to address weaknesses in these studies.

In a meta-analysis, Nishi et al. (1997) identified five studies. Three of the studies included smoking cessation as a main outcome, whereas in the other two studies smoking cessation was not the main outcome. Although the results of this meta-analysis seem to demonstrate the positive effects of exercise on smoking cessation, the limited number of studies could not establish robust conclusions.

Two reviews conducted by Ussher et al. (2000, 2005) identified eight chronic studies on exercise and smoking cessation where participants were trying to quit smoking. Of these studies only one by Marcus, Albrecht, King, Parisi, Pinto, Roberts et al., (1999) offered some substantial evidence for positive long term effects of exercise. In that study Marcus, et al. (1999) examined the effects of a supervised 12 month exercise programme. The programme consisted of thrice weekly exercise sessions at a vigorous intensity; with each session lasting 30 to 40 min. It was shown that a year after the end of the treatment, participants in the exercise condition achieved approximately double the smoking abstinence rates of those in an equal contact control condition (Marcus et al., 1999).

In a four week study, the results of exercise supplemented with behavioural counselling were compared against two interventions (Martin, Kalfas & Patten, 1997). One intervention involved a smoking cessation programme which included the attendance of 'nicotine anonymous' meetings. The other intervention included behavioural counselling and nicotine gum. The conclusion of the study was that more smokers in the exercise plus behavioural counselling group were more likely to quit than those in the other two groups.

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However, the superiority of the exercise plus behavioural counselling group was not maintained over the other groups at six and twelve months follow up. Although, this study provides support for the beneficial effects of exercise, it does not provide support for the long-lasting effect of exercise. When the effectiveness of exercise was compared against nicotine gum (Hill, Rigdon & Johnson, 1993), there were no significant differences. These findings suggest that exercise could be equally effective on smoking cessation such as a NRT (Hurt et al., 1998).

In four studies, that examined the effects of exercise on smoking cessation, the exercise group received more staff contact time than the control group (Hill, 1985; Marcus, Albrecht, Niaura, Abrams, & Thompson, 1991; Martin et al., 1997; Taylor, Houston-Miller, Haskell & Debusk, 1988). This is raising the question as to whether the outcomes for abstinence were due to exercise alone or to the additional emotional support. The rest of the studies had small sample sizes. Overall, the reviews by Ussher et al. (2000, 2005) suggests that there is evidence of the effectiveness of exercise on smoking cessation, but the effects are not maintained in the long term. The majority of the studies included in this review did not provide evidence for the activity level of the individual after the exercise programme had finished. This may suggest that people did not maintain their activity level. The fact that more people in the exercise conditions quit by the end of the intervention in comparison with other interventions may suggest that exercise is potentially more effective than other interventions.

Taylor and Ussher (2005) reviewed ten chronic exercise programmes on smoking cessation, where participants were trying to quit smoking (eight of which were included in the previous reviews by Ussher et al., 2000, 2005) and five studies on the acute effects of

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exercise on smoking cessation with temporary abstinent smokers. The results of their review added that an exercise counseling intervention could alleviate feelings of tension, anxiety, irritability; stress (Ussher, West, McEwen, Taylor & Steptoe, 2003) and negative affect (Bock, Marcus, King, Borrelli & Roberts, 1999). These effects were evident immediately after each exercise session and at the end of the exercise programme, but were not maintained over a protracted period. Overall, the chronic exercise studies did not offered substantial evidence of the effects of exercise in promoting long term smoking cessation, although they provided evidence for the effectiveness of exercise immediately after each exercise session (Bock et al. 1999; Ussher et al. 2003; Martin et al. 1997).

One mechanism explaining the effects of exercise on smoking cessation may be due to the psychological benefits from each single session of exercise (Grove, Wilkinson, & Dawson, 1993). Therefore, in order to explore the mechanism for the beneficial effects of exercise, Taylor and Ussher (2005) also included in their review studies investigating the effects of a single exercise bout (acute effects of exercise) on smoking cessation. The acute studies concluded that a single bout of aerobic exercise had beneficial effects on urges to smoke and tobacco withdrawal symptoms, (e.g., depression, tension, irritability, anxiety, stress, lack of concentration) during temporary smoking abstinence (Daniel, Cropley, Ussher & West, 2004; Pomerleau, Scherzer, Grunberg, Pomerleau, Judge, Fetig & Burleson, 1987; Taylor et al., 2005; Thayer, Peters, Takahashi & Birkhead-Flight, 1993; Ussher, Nunziata, Cropley & West, 2001). This abstinence elicited the same withdrawal symptoms associated with total abstinence (Daniel et al., 2004; Ussher et al., 2001; West, Hajek, Birkhead-Flight & Belcher, 1989). Studies gave clear evidence that a single session of aerobic exercise can reduce the urge to smoke and tobacco negative affect (Bock et al., 1999; Daniel et al., 2004; Pomerleau et al., 1987; Taylor et al., 2005; Thayer et al., 1993; Ussher et al., 2001). The



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lowest intensity exercise that produced positive effects, relative to a passive control, was five minutes cycling at 50-60% of HRR (Daniel et al., 2004). The shortest duration of exercise that had a positive effect on cigarette cravings and withdrawal symptoms was 5 minutes and the longest lasting duration of exercise to have an effect was 10 minutes (Daniel et al., 2004; Ussher et al., 2001). All the studies in this review showed positive effects on withdrawal symptoms and cravings with only one study reporting an increased time until next cigarette (Thayer et al., 1993).

More recently, Taylor et al. (2007) conducted another review of literature investigating the acute effects of exercise on smoking cessation. The review included 14 studies, three of which are studies from the current thesis. All studies included in the review, apart from two studies conducted by Daley, Oldham and Townson (2004) and Everson, Daley, and Ussher (2006), showed a fairly consistent pattern of reduction of withdrawal symptoms and cravings during and following exercise. Withdrawal symptoms that were reduced by exercise included negative affect, stress, depression, tension, anxiety, irritability, poor concentration and anxiety. The failure in the studies by Daley et al. (2004) and Everson et al. (2006) to show an effect of exercise on withdrawal symptoms was due to methodological limitations. Daley's failure to find any statistical differences is due to the small sample size, although in the exercise condition there was a trend indicating a reduction in craving scores over time. The study by Everson et al. (2006) compared the effects of two different exercise intensities (55% versus 44% of age-predicted heart rate) but failed to show a significant difference on withdrawal symptoms. This absence of a significant difference seems to be due to the relatively similar exercise intensities (55% versus 44% of age-predicted heart rate).

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Taylor et al. (2007) reported that the studies conducted by Pomerleau et al. (1978) and Daniel et al. (2004) aimed to test the effects of different intensities of exercise on cravings and withdrawal symptoms, but only Daniel et al. (2004) noted statistically significant differences. The failure of Pomerleau et al.'s (1978) study to detect significant differences between vigorous- and light-intensity exercise may be because of the small sample size. The study included with only ten participants and without a resting control group it was not possible to determine if the low intensity condition had any effect. Moreover, the participants had only 30 minutes of abstinence prior to treatment suggesting that baseline cravings, which were not recorded at the outset, may have not been particularly high and may have undermined the effects of exercise.

In Daniel's et al. (2004) study, cycling at a rate of 40–60% HRR for 5 minutes reduced cravings compared with cycling at 10–20% HRR and the effects lasted for at least 10 minutes following exercise. This study was the first to show a dose response relationship between intensity of exercise and length of effects on desire for a cigarette and withdrawal symptoms. Although the mechanism responsible for the beneficial effects of exercise has not been investigated, the fact that low and moderate intensity groups had different outcomes, and that effects lasted beyond the exercise partly eliminate distraction as a possible mechanism.

In an attempt to eliminate distraction as a possible mechanism for the effects of exercise and in order to avoid finding effects from the exercise due to a negative emotional response to a passive control condition, Ussher et al. (2001) used a between subject design that involved two resting control groups. One group involved a distraction (neutral video about gardening) and another was a pure resting group. The exercise group cycled while watching the neutral video. The two control groups did not differ in their

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reporting of desire and withdrawal symptoms. It would appear that additional effects were gained from the exercise, beyond distraction or engagement in another task (watching a video), with a fairly minimal exercise dose.

Moreover, Daniel, Cropley and Fife-Schaw (2006) examined the effects of ten minute moderate intensity exercise (on 40% - 60% of heart rate reserve) against a ten minute cognitive distraction task. In congruence with previous research, it was concluded that during and immediately after exercise, withdrawal symptoms and desire to smoke relative to the baseline were rated lower. Conversely, cognitive distraction did not produce any effects in withdrawal symptoms and levels of desire to smoke. These findings suggest that the effects of exercise are not caused only by distraction. One obvious objection to the use of the cognitive distractive task is that for some individuals its effect may have been overbearing, perceived by some as being stressful and so causing them to act adversely, i.e. to smoke (Taylor et al., 2007).

To sum up, studies that involved chronic exercise programmes to investigate the role of exercise for helping people to quit smoking have shown limited effects on cessation rates, albeit almost all trials have been methodologically limited e.g., by sample size, poorly controlled conditions and measures (Taylor & Ussher, 2005). They have also focused on exercise for weight management and overcoming fear of weight gain and not on the effects of exercise on smoking withdrawal symptoms and cravings. In order to investigate if and how exercise could have an effect on smoking cessation by influencing smoking withdrawal; a number of studies investigated the acute effects of exercise. Reviews and intervention studies showed that a single bout of aerobic exercise at a relative moderate intensity has an acute effect on cravings, withdrawal symptoms and affect, particularly in laboratory settings. The extent of the reductions in cravings is encouraging and

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comparable with that of the acute responses to glucose and oral NRT (West, Courts, Beharry, May & Hajek, 1999). West et al. (1999) showed a reduction in ratings of 'strength of desire to smoke' of up to 1.0 point on a seven point scale for glucose against placebo; whereas exercise shows a reduction in ratings of desire to smoke compared with control groups (Taylor and Ussher, 2005). The effects of exercise are greater on cravings and withdrawal symptoms than those of oral NRT. For example the effects of oral NRT were not evident until 10 minutes after its taking (Shiffman, Shadel, Niaura, Khayrallah, Jorenby, Ryan et al., 2003; Ussher & Taylor, 2005).

Hitherto the mechanism explaining the effects of exercise on cravings and withdrawal symptoms has not been investigated. Researchers (Daniel et al., 2001, 2006; Ussher et al., 2001, 2006) provide evidence that the effects of exercise are not due to distraction. Other explanations remain to be tested such as whether the effects of exercise on cravings are due to biochemical changes, psycho-social or psycho-biological. Given the beneficial effects of exercise on mood and affect in non-smokers, one way that the present thesis contributes to the literature is by investigating whether mood and affect is the mechanism responsible for the exercise effects. Previous research in this area of exercise and smoking cessation has not investigated the possibility that mood mediates the effects of exercise on cravings.

The study on the effects of exercise on smoking cessation is still in its infancy and further studies are needed to extend and enrich this field of research. By using more rigorous experimental designs, the studies included in the present thesis improve the understanding of the effects of exercise on smoking cessation.

## **2. 6 The present research: aims and contributions**

### **2. 6.1. Methodological considerations: Experimental design**

Previous studies investigating the acute effects of exercise on tobacco cravings have employed between-participant designs. In these studies, randomization was shown to eliminate group differences at baseline (Bock et al., 1999; Daniel et al., 2003; Daley et al., 2004; Daniel et al., 2006; Everson et al., 2006; Pomerleau et al., 1987; Thayer et al., 1993; Ussher et al., 2006; Ussher et al., 2001). Although randomization has been shown to be successful in large sample sizes, in small sample sizes may be inadequate to cancel out extraneous variables (Thomas & Nelson, 1996). Using a within-participants design at this early stage in this line of research will broaden the range of evidence from different research designs by examining the effects of exercise at the intra-individual level. In addition, all previously discussed studies were conducted by the same experimenter. Therefore, they may have involved experimenter bias since the condition to which participants were allocated was known to the researcher during post-treatment follow-up assessments. In order therefore to eliminate experimental bias, the second study of this thesis will extend the methodology used in previous studies and will adopt a blind design.

### **2. 6.2. Smoking abstinence**

A common research paradigm to examine the acute effects of exercise on smoking outcomes is the involvement of smokers who are not quitting, but who abstain from smoking for a number of hours prior to the study. Although some studies have reported the acute effects of exercise on affect during on-going quit attempts (e.g., Bock et al., 1999; Grove et al., 1993) the effects are difficult to establish given the varying degree of

withdrawal symptoms experienced over time, following cessation. Pomerleau et al. (1987) and Thayer et al. (1993) required a 30 – 45 minutes smoking abstinence prior to their studies in order to examine the effects of exercise on cravings and mood. Nevertheless, they had one or more methodological limitations that influence their findings. Their limitations include: no passive control group to compare with exercise, a small sample size, a lack of control over exercise intensity in a naturalistic study, and the short periods of deprivation which resulted in low cravings and a masking of the scope of the study to examine cravings.

Previous ‘well-controlled’ studies (Daniel et al., 2006; Daniel et al., 2004; Everson et al., 2006; Ussher et al., 2006; Ussher et al., 2001) have required about 15 hours of smoking abstinence to elevate urges to smoke prior to exercising in order to simulate deprivation, a commonly used paradigm in addiction research to test the effects of different interventions. It is not known what the size of effects would be following briefer abstinence e.g. two to three hours, when many moderate smokers may begin to experience a greater urge to smoke. A further objective of the studies in the present thesis is to investigate the effects of exercise in abstainer smokers who were deprived over different periods of time.

### **2. 6.3. Mode, Intensity and duration of exercise and follow-up assessments**

Previous studies have examined the effects of forced moderate-intensity exercise on withdrawal symptoms and urge to smoke (Bock et al. 1999; Daley et al., 2004; Daniel et al., 2006; Daniel et al., 2003; Everson et al., 2006; Pomerleau et al., 1987; Thayer et al., 1993; Ussher et al., 2001; Ussher et al., 2006). Self-Determination Theory (Ryan & Deci, 2000) posits that when participants are given choice and control over exercise more positive affective responses are likely to occur. In addition, research with non-smokers

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has shown that overweight and sedentary adults reported greater affective responses associated with exercise when they self-selected their exercise intensity (Ekkekakis & Lind, 2006; Lind et al., 2005). Bearing in mind that the majority of smokers are sedentary and practice an unhealthy behaviour which may act as a barrier to exercise, one should take into account not only which exercise intensity is effective by a physiological standpoint but also what is tolerable and enjoyable from a psychological perspective. Consequently, if enhanced affect is an important mediator in reducing urges to smoke, then it is possible that self-paced exercise may be more advantageous than forced-intensity exercise for reducing cigarette cravings. The present thesis seeks to maximise the potential effects of exercise through allowing a degree of choice or 'self-pacing' in the exercise task.

All but three studies (Bock et al., 1999; Thayer et al., 1993; Ussher et al., 2006) used an indoor cycle ergometer at a low- moderate intensity as a mode of exercise. Research on non-smokers has shown that walking often undertaken at low-moderate intensity (walking is a convenient mode of exercise for most people without contraindicated pathology) can enhance mood, and positive affect (Ekkekakis et al., 2000). Walking is also a familiar form of exercise to anyone, is inexpensive, readily accessible and has low risk of musculoskeletal injuries. Therefore, walking may be a more attractive form of activity to smokers, a population considered to be generally sedentary. In order to establish guidelines for the use of exercise as a mean of reducing urges to smoke and withdrawal symptoms, this thesis examines the effects of walking as a mode of exercise on cravings and smoking withdrawal symptoms.

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The review of the acute effects of exercise on smoking cessation revealed that previous studies examined only the effects of short exercise duration (5 -10 minutes) on withdrawal symptoms and cravings (Daniel et al., 2004; Ussher et al., 2001).

Furthermore, the longest post exercise following up period examining the effects of exercise was 10 minutes (Daniel et al., 2004; Ussher et al., 2001). The duration of the acute effects of exercise on affect have been widely considered in the literature (Biddle, 2000). The mechanisms responsible for the effects of exercise may involve both physiological and psycho-social processes that span over different periods of time. For example, brief exercise may be enough to serve as a distraction from cognitions such as an urge to smoke particularly if some cognitive demands are required during the exercise. On the other hand, longer periods of exercise may result in both distraction and enduring biochemical changes in the mesolimbic dopaminergic system. Given the promise of these early experimental studies that used short duration exercise (lasting 5 to 10 minutes), it seems necessary to undertake further research in order to examine the effects of longer exercise sessions on smoking deprivation outcomes. Therefore in the first study of this thesis the exercise duration will be longer than in previous studies and equal to 17 to 20 minutes of continuous exercise.

In studies involving non-smokers, the positive affective changes during moderate to light intensity exercise, could be extended into exercise recovery and could last for up to several hours (Ekkekakis et al., 2000; Ekkekakis et al., 1999; Van Landuyt et al., 2000).

If stress and negative affect increases smoking appetite, the elevated positive affect and reduced negative affect, if sustained, may suppress smoking urges and withdrawal symptoms. The well controlled studies by Ussher et al. (2001) and Daniel et al. (2004) used a follow-up period after the exercise for no longer than ten minutes in order to



examine the duration of the exercise effects. It is necessary to establish whether exercise only causes a short-lived reduction in urges (i.e. up to ten minutes) or these effects can be sustained over a longer period. It is also conceivable that follow-ups beyond ten minutes post-exercise could reveal elevated urges to smoke in response to exercise. Moreover, the longer the observed effects last after exercise, one may be less inclined to offer distraction as the primary mechanism for any effects on cravings. Further studies are therefore needed to identify the duration of the positive effects of exercise post-treatment. In order to examine the duration of the exercise effects studies in this thesis will include longer follow up periods. In the first study on this thesis the follow up period will be extended for up to 20 minutes.

### **2. 6.4. Sample**

Previous studies (Daniel et al., 2004, 2000; Everson et al., 2006; Ussher et al., 2001, 2006) focused on sedentary populations. Smokers tend to be less active than the general population and it may be that exercise provides a greater challenge and possibly distraction from urges to smoke following abstinence. It is therefore important to also determine the effects of exercise on urges to smoke amongst those who are typically more physically active. The present thesis therefore will examine the effects of exercise in more physically-active abstinent smokers.

### **2. 6.5. Possible mechanisms**

If exercise is to be prescribed as a behavioral intervention to aid smoking cessation, it is also vital to understand why exercise has beneficial effects. If a plausible mechanism can be shown then this adds support for a causal effect. Furthermore, by understanding how

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exercise has an effect on smoking withdrawal then more effective interventions and guidance can be developed.

Previous studies on the acute effects of exercise only examined the effects of exercise on withdrawal outcomes but did not explore the mechanism of these effects. A number of mechanisms could account for why acute exercise appears to reduce cravings and withdrawal symptoms, such as stress reduction (deactivation) and activation. The Deprivation Reversal Model (Schachter, 1978) suggests that during temporary smoking abstinence there is a decrease in arousal (low activation) and an increase in emotional stress (negative valence), which both returns to a “normal level” after smoking a cigarette. Nicotine (as a resource) therefore provides a paradoxical mode of mood regulation through both stimulating and stress-reducing properties. In 1973 Stanley Schachter described *“Nesbitt’s paradox... a perverse contatenation of data which simply doesn’t make sense”* (Schachter, 1973, p. 148). The core of the paradox was that while smoking leads to sympathetic arousal, in psychological terms smokers report feelings of relaxation: “The physiological and psychological effects of smoking a cigarette are seemingly in contradiction to each other. When smokers smoke, their level of physiological arousal increases while they report themselves as calmer and more relaxed” (Nesbitt’s paradox, 1973, p. 137 cited in Parrott, 1998).

Nesbitt’s Paradox (Schachter, 1973) was explained by Parrott (1998) with evidence that smoking a cigarette has independent effects on arousal and emotional stress. It was also suggested that interventions to mimic the effects of smoking a cigarette could aim to increase emotional arousal such as energy or vigor, and reduce emotional symptoms of stress such as tension. Given that single sessions of exercise appear to have both

stimulating and stress-reducing properties among non-smoking populations (Biddle, 2000; Ekkekakis, 2003; Taylor, 2000), research is needed to determine whether these specific exercise related emotional changes occur during temporary smoking withdrawal and whether they independently mediate changes in cravings for a cigarette. In particular there is a need to examine whether those effects of exercise on cravings are mediated by changes in activation (energy, vigor), and tension. A scope of the present investigation will be the examination of this mechanism.

### **2. 6.6. Measures of Mood, affect, withdrawal and cravings**

Numerous studies have assessed tobacco cravings and withdrawal symptoms with the use of single-item self-report measures such as desire to smoke and strength of desire to smoke and through the items of the Mood and Physical Symptoms Scale (MPSS) (Bock et al., 1999; Daniel et al., 2006; Daniel et al., 2004; Everson et al., 2006; Pomerleau et al., 1978; Thayer et al., 1993; Ussher et al., 2001, 2006). At this early stage of research in this field, it is essential that cumulative evidence is founded on more than one single measure.

Hoffman, West and Gilbert (2004) recently noted that multi-item measures of tobacco withdrawal and cravings are likely to perform better than single items, based on psychometric principles. Shiffman et al. (2004) also considered whether urges to smoke were a uni- or a multi-dimensional construct. In developing the Questionnaire for Smoking Urges (QSU), Tiffany and Drobes (1991), proposed that cravings should be construed as two dimensional: namely an intention and desire to engage in smoking behaviour which is anticipated as pleasant, enjoyable and satisfying (desire-behave), and anticipation of relief from negative affect through smoking (desire-affect relief). Whilst Shiffman et al. (2004) note that there may be evidence that the two scales of the QSU are sensitive to cessation of smoking, less is known about their sensitivity to detect the effects of aids to smoking

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cessation. Sayette et al. (2000) suggested that further evidence was needed to support the independence and sensitivity of the two dimensions in the Tiffany and Drobes (1991) scale. The aim of the first study of the current thesis will be to examine the effects of exercise on cravings by using the two-dimensional multi-item measure of cravings (QSU).

Shiffman et al. (2004) also considered the relative merits of single versus multi-item scales of affect in smoking withdrawal research and recommended:

*“Researchers should also consider the advantages of including published and validated measures of mood (e.g., PANAS and POMS). The inclusion of these general measures can provide benchmarks that will allow the results of smoking withdrawal studies to be integrated with and related to other studies of affect.”* (p. 605)

In the general affective literature there is criticism for studies using measures such as the POMS, STAI and the PANAS. Researchers argue that these measures report changes in distinct states without being informative of the nature of the effects of exercise under various conditions. It is therefore recommended that researches should distinguish between the many constructs that fall under the affective umbrella and choose a measure that is appropriate to their research question.

While a clear distinction between emotions, mood, and affect has not been made in the literature concerning the measurement of smoking withdrawal symptoms, a basic measure of affect may be more closely associated with the underlying neurophysiological changes induced by exercise. Exercise-related affective responses in non-smokers have been

examined in the circumplex (Russell, 1980) model of affect (Ekkekakis, 2003; Ekkekakis & Petruzzello, 2000, 2002).

Ekkekakis et al. (2000) used the circumplex model of affect to examine the acute effects of walking on affect, in non-smokers. Results of their investigation demonstrated acute effects of walking with positive changes in affective activation and valence occurring during exercise, but then returning to a state of calmness and activation at ten minutes post-exercise. The circumplex model rather than focusing on specific emotional responses, it considers basic affect along the two dimensions of activation and valence. The circumplex model has not been used to study affective responses to smokers, therefore it would be interesting to examine whether the effects of exercise on affect, in deprived smokers, who suffer from negative affect due to abstinence, will follow a similar pattern as in non-smokers. Negative affect and stress is associated with increased smoking behaviour and cravings. Furthermore smokers report that smoking calms them (Parrott, 1998). If exercise induces feelings of relaxation and calmness in smokers, then they might be less reactive to stressors that might lead them to smoke (Emmons et al., (1989).

A scope of the first study in this thesis will be to examine the effects of exercise on affect using the circumflex model of affect.

### **2. 6.7. Ad libitum smoking behaviour**

In previous studies measurements of withdrawal symptoms and cravings even during the post-exercise follow-up period took place in laboratory conditions. It would have been interesting to examine whether the effects of exercise could be maintained in the natural environment where participants are free to smoke. Research with non-smokers indicated that the positive affective changes of exercise could be extended for up to several hours

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post-exercise. If positive affect is associated with an overall reduction in cravings and withdrawal symptoms it would have been interesting to know whether these effects would be reflected in the time smokers chooses to smoke their next cigarette (*ad libitum*) after leaving the laboratory.

Only two studies (Thayer et al., 1993; Reeser, 1983) have shown that exercise can extend the time to smoking the next *ad libitum* cigarette. Thayer's et al study (1993) took place in a naturalistic setting where participants were asked to rest and not smoke for 45 minutes before being instructed to walk briskly (loosely defined) for five minutes or remain passive on 12 occasions. The exercise reduced the urge to smoke and extended the time to *ad libitum* smoking, reported in a self-recorded diary, by an average of 8 minutes. In Reeser's (1983) study, covert observation in a laboratory (with freedom to smoke or read) showed that 20 minutes of exercise decreased cravings and increased the time to smoking the next cigarette by seven minutes and 24 minutes for an aerobic activity, and stretching and isometric condition, respectively, compared with a passive control condition. Only 15% of participants did not smoke following the passive condition, compared with 27% during the 30 minutes following the two exercise conditions.

These two studies however had limitations. The precise dose of exercise was unclear in the Thayer et al. study. In addition, the environment in which participants exercised and completed questionnaires was not controlled and it is therefore not certain that it was free of distractions and social interaction which may have affected the results. In Reeser's study the laboratory follow-up period, during which smoking behaviour was measured at the experimental environment, may have interfered with *ad libitum* smoking. For example, if the effects of exercise on smoking were due to priming effects, participants might have

associated exercise with non smoking or might have suspected that they should not smoke. Nevertheless, according to Bargh and colleagues, the priming effects are short lived and they do not last when people change environment and content. Therefore, an aim of the present investigation will be to examine participant's ad libitum smoking behaviour after leaving the experimental settings and are exposed to a different environment where they are free to smoke. Knowledge of the duration of exercise effects may have important implications for the clinical utility of exercise in smoking cessation.

### **2. 6.8. Responses to cue-elicited cravings**

To examine the long-term effect of exercise after participants leave the laboratory on their time to smoke their next cigarette, research should take into consideration that the severity of the symptoms experienced during smoking abstinence may be associated with a number of factors. These factors include: degree of tobacco dependence, length of abstinence, and presence of smoking cues such as exposure to environment and situations that would normally elicit a strong desire to smoke (Ussher & Taylor, 2005). Therefore, experimental procedures that do not expose smokers to smoking cues may not be ecologically valid (Carter & Tiffany, 1999; Ussher & Taylor, 2005).

Stress and smoking cues (such as situations and environment that may elicit strong desire to smoke) have been shown to increase cravings, withdrawal symptoms and the number of cigarettes smoked (Carter & Tiffany, 1999), and also increases the likelihood of relapse (Chassin, Presson, Sherman & Kim, 2002; Manning, Catley, Harris, Mayo & Ahluwalia, 2005). In addition, non-abstaining participants smoked more cigarettes and experienced more urges to smoke on occasions with higher numbers of negative events and higher levels of perceived stress (Todd, 2004). It has been proposed that when levels negative

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affect increase and enter consciousness in response to abstinence (e.g. stress and smoking cues) information processing is biased in ways that promote renewed drug administration (Baker et al., 2004; Shiffman & Waters, 2004). As a result, recent experimental studies have examined whether treatments (e.g., NRT and naltrexone) attenuate increases in cue-elicited cravings in order to prevent relapse (Carter & Tiffany, 1999; Hutchison, Monti, Rohsenow, Swift, Colby, Gnys, Niaura & Sirota, 1999; Morissette, Palfai, Gulliver, Spiegel & Barlow, 2003; Niaura, Sayette, Shiffman, Glover, Nides, Shelanski et al., 2005; Shiffman, Shadel, Niaura, Khayrallah, Jorenby, Ryan et al., 2003; Tiffany, Cox & Elash, 2000; Waters, Shiffman, Sayette, Paty, Gwaltney & Balabanis, 2004).

No studies have yet examined whether a single session of exercise is useful for the regulation of stress and cue-elicited cravings and withdrawal symptoms. Further, no studies have examined whether the effects are the same for a variety of types of cues (Carter & Tiffany, 1999). Given that exercise can acutely attenuate increases in psychological and physiological responses to stress in non smokers (Taylor, 2000; Hamer, Taylor & Steptoe, 2006), one may anticipate that cue-elicited cravings and withdrawal symptoms may also be moderated by exercise. If relatively brief periods of exercise can be shown to attenuate increases in stress and cue-elicited cravings then this would further support physical activity as a useful behavioural aid for relapse prevention and regulation of ad libitum smoking. An aim of the present investigation is the examination of the exercise effects on cue elicited cravings and withdrawal symptoms.



## **2. 6.9. Rationale of present investigation**

### **Study 1**

Extending previous research in the area, this study will examine the effects of one mile walking (estimated to last 15 – 20 minutes) at a preferred intensity on urges to smoke mood changes and affect in active smokers. Participants will be required to abstain from smoking for 15 hours prior to the study in order to simulate deprivation and elevate urges to smoke and negative affect. This is a commonly used paradigm in addiction research to test the effects of different interventions. Furthermore, study 1, will use a within-participants counterbalanced design. This is important in order to broaden the range of evidence from different research designs and examine the effects of exercise on urges to smoke, cravings, mood and affect at the intra-individual level. Further, this study will examine whether the effects of exercise would last for at least 20 minutes following exercise. This is the longest follow up period used in the study of exercise and smoking cessation.

A unique contribution of Study 1 is the exploration of the mechanisms of the effects of exercise on smoking. Study 1 will examine the effects of exercise on tension and activation as proposed by Nesbitt's paradox. Moreover study 1, will examine the effects of exercise on affect using the circumplex model of affect. Lastly, the study will determine if any effects of exercise on urges to smoke are mediated by changes in mood and affect.

### **Study 2**

Study 2 will extend knowledge on the acute effects of exercise on cravings, by overcoming a number of limitations of the previous studies in the area and will extend findings of study

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1. Study 2 will also examine the effects of self-paced walking versus an equal passive control condition on cravings and withdrawal symptoms.

A unique contribution of Study 2 is the examination of the effects of exercise on cue elicited cravings. In study 1 treatment effects have been observed for up to 20 minutes after exercise in controlled laboratory settings where participants did not have the freedom to smoke. Extending study 1, Study 2 will examine whether these exercise effects on cravings and withdrawal symptoms will be resistant under conditions which would normally increase cravings, such as stress or the present of smoking cues. In order to examine the effects of exercise on cue elicited cravings during the post exercise following up period participants will be exposed to a variety of stressors and a smoking cue (a lit cigarette) all previously used to elicit stress and a strong desire to smoke. Moreover, study 2 aims to examine the length of the exercise effects on smoking behaviour after people leave the laboratory and are exposed to their natural environment where they have the freedom to smoke. Examining the smoking behaviour outside the experimental settings is important because it eliminates experiment bias in the self reported measures. The effects of exercise on smoking could be due to priming effects, which mean that people might have associated exercise with non smoking or might have suspected that they should not smoke. Priming effects are short lived and are not lasting after changing environment and content (Bargh, J. A., Chen, M., & Burrows, L., 1996). Therefore by measuring smoking behaviour when people have left the experimental settings and are exposed to a different environment it eliminates such experiment bias.

In contrast to the previous studies in the area that used a smoking deprivation period of 15 hours prior to the study, study 2 will examine the effects of exercise on smokers who will be smoking abstinent for 2 hours. The 2 hour smoking abstinence is used in order to avoid

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reaching a ceiling effect on cravings and withdrawal symptoms in the passive control group which as a result might disguise the purpose of eliciting cravings due to stressors and the smoking cue.

In particular, after two hours smoking abstinence, and using a between participants blind design, Study 2 aims to determine if a fifteen minute self-paced walk, will attenuate increases in cue-elicited cravings and withdrawal symptoms in comparison with a passive control group. In addition, the study aims to examine whether exercise would extend the time to ad libitum smoking, and if this time would be predicted by cigarette cravings at the end of experimental procedures.

### **Study 3**

Extending study 2, the aim of Study 3 is to examine the effects of a 15-minute self paced walk on cravings and withdrawal symptoms associated with two hours smoking abstinence. Study 3 will examine the effects of exercise on a smoking cue only, the presentation of a lit cigarette. By examining the effects of exercise on the individual cue the study helps identify the potency of the lit cigarette to elicit cravings and withdrawal symptoms which will enrich knowledge in cue-reactivity research. Determining and identifying the efficacy of different smoking cues associated with smoking craving and relapse is also important in order to further examine the relapse-preventing efficacy of exercise. Lastly, this study aims to examine the time that participants smoked their first cigarette after leaving the laboratory and compare the findings with those of study 2.

### Study 4

Extending studies 2 and 3, study 4 will examine the effects of a self paced walk versus passive waiting on withdrawal symptoms and cravings, in response to a smoking cue (lit cigarette) in non-abstinent smokers. Study 4 aims to examine whether the time before participants smoke their next ad libitum cigarette would be extended following exercise in comparison with the results of the previous two studies that used smoking-abstinent participants. By examining the effects of exercise among non-abstinent smokers, Study 4 controls for unrealistically high levels of cravings and examines the potency of the smoking cue to elicit craving and withdrawal symptom responses. Furthermore, it is important to explore the effects of exercise in cue-elicited cravings in smokers during different periods of smoking abstinence and lack of abstinence. Recognising the condition of the smoker is a critical determinant in craving response and could identify the relapse-preventing efficacy of exercise

## **Chapter 3**

### **3. Study 1**

#### **3. 0 Introduction**

The purpose of Study 1 was to investigate whether and for how long, a self-paced one-mile walk during temporary abstinence would reduce urges to smoke, and enhance, mood and affect. Moreover, Study 1 aimed to determine whether any effects of exercise on urges to smoke were mediated by affect.

Study 1 contributes to the extant literature in a number of ways. First, Study 1 examines the effects of self-paced (as opposed to imposed-intensity) walk (completion of one mile, with a variable duration due to the different preferred speeds) on urges to smoke, cravings, mood and affect. Second, Study 1 extends previous research by using multi-item measures (in addition to a single-item measure used in previous studies) of mood and urges to smoke. Third, a within-participants counterbalanced design is implemented to examine the effects of exercise on urges to smoke, cravings, mood and affect at the intra-individual level. Fourth, given the evidence that smoking may act as both a stimulant and relaxant (see Parrott, 1998 for a review) the present study will investigate whether exercise could mimic the effect of smoking by increasing arousal (energy) and reducing emotional stress (tension). Study 1 is the first study in the area of exercise and smoking cessation designed to explore this mechanism. Fifth, Study 1 aims to examine the effects of exercise on affect by using the circumplex model of affect. The circumplex model of affect examines

affective valence and activation independently and the same time. This is important as it can show the interaction between valence and activation and therefore could provide a better explanation of the effects of exercise on affective states. The circumplex model of affect has not been used before in the study of exercise and smoking cessation and therefore it is a unique contribution of study 1.

Sixth the study aimed to examine whether the effects of exercise on urges to smoke are mediated by mood and affect. Finally, Study 1 follows smoking behavior for 20 minutes, which is the longer follow-up period used in previous studies of exercise and smoking cessation (Daniel et al., 2004; Pomerleau et al., 1987; Thayer et al., 1993; Ussher et al., 2001).

### 3. 0.1. Hypotheses

The present study will test the following hypotheses:

***Hypothesis 1:*** A self-paced one-mile walk, in comparison to a passive control group, would (a) reduce cravings and urges to smoke; (b) would increase the specific moods of energy and vigor and reduce tension; and (c) within the context of the circumplex model, will increase the basic affect measures of activation and valence. Furthermore, the exercise effects would last for at least 20 minutes following exercise.

***Hypothesis 2:*** Changes on the specific moods of energy, tension and vigor will mediate the effects of exercise on cigarette craving and urges to smoke and changes in measures of affective valence and activation will mediate the effects of exercise on cigarette craving and urges to smoke.

### **3. 1 Materials and methods**

#### **3. 1.1. Participants**

Participants were recruited through public advertisements and were screened by telephone. Participants had to be between 18 and 50 years of age, smoke at least ten cigarettes daily, not pregnant, and not receiving any psychiatric treatment or suffering any medical condition that was contraindicated for physical activity (Thomas et al., 1992).

Using Cohen's pairwise calculations, inter-correlations between levels, and effect sizes from Daniel et al. (2004) and Ussher et al. (2001), estimated that for a within-participants design, with a power of .80, and alpha of .05, a sample size of 15 participants was needed to detect differences on the primary outcome variable of 'craving to smoke' (Maxwell & Delaney, 2004; Vonesh & Schork, 1986). During recruitment, two respondents were excluded, one due to a restricting medical condition and the other due to receiving psychiatric treatment, five volunteers were also excluded due to smoking prior to the study, while two were excluded as they did not complete both sessions of the experiment resulting in 15 healthy volunteers (mean age = 25.6 years, SD = 6.5; average number of cigarettes smoked per day 16.6 SD = 10.6).

#### **3. 1.2 Design and Procedure**

The study was approved by the University Research Ethics Committee. Participants were asked to abstain from smoking for approximately 15 hours (from the previous evening) and to attend two laboratory sessions on different days, at the same time of day. Upon arrival at the laboratory participants provided an informed consent (Appendix 2) and completed a

medical Questionnaire (PARQ) (Appendix 1). Expired carbon monoxide (CO) levels were used to confirm abstinence (<10 ppm) upon arrival for testing (Bedfont Smokerlyzer). After the protocol was explained and background and baseline measures were taken, participants were, within a randomized-crossover design, assigned (by random numbers) to begin with either a walking or passive condition. During both conditions they wore a POLAR advantage heart rate monitor and data were downloaded to a PC for calculation of exercise intensity. Throughout the sessions, the interaction between researcher and participant was kept to a minimum (e.g., written instructions at the first administration of the questionnaires).

Exercise condition: After a brief familiarization with the treadmill, the exercise session consisted of a two-minute warm-up (at 4 kph) followed by one mile of brisk walking on a horizontal treadmill at a preferred intensity and then a two-minute cool down. It was estimated that the walk would take approximately 15 to 20 min. Participants were instructed to imagine they were briskly walking as if to catch a bus, but not to the point of breathlessness. The treadmill control panel was out of the view of the participants so they were not aware of the cadence that they were exercising. In order to allow an element of self-pacing, participants were asked to request a quicker or slower pace throughout the session as desired. Every two minutes during the walk, participants provided a rating of perceived exertion (RPE) using the 6–20 Borg scale (Borg, 1998), with the scale positioned in front of the treadmill in large font (see appendix 3). The experimenter monitored heart rate response throughout, out of view of the participant. Immediately after the exercise session the participants remained seated in the laboratory for 20 minutes.



**Control Condition:** The control condition involved passive waiting (sitting quietly) without access to reading material (in order to maintain equal cognitive load across the group) for 40 minutes, and completion of the same measures as in the exercise condition, at equivalent time points. Previous studies confirmed that passive sitting, as a control condition for examining the acute effects of exercise on urges to smoke, produces relatively stable measures over the duration of a 20-minutes experiment (Daniel et al., 2004; Ussher et al., 2001).

### **3. 1.3. Measures**

Background data were collected for age, gender, weight, height and average number of cigarettes smoked per day. Nicotine dependence was assessed using the Fagerström Test for Nicotine Dependence (FTND; Heatherton et al. 1991) (See Appendix 4). Levels of participant's physical activity during the previous week were assessed by self-report using a 7-day recall of physical activity measure (Blair et al. 1985) (See Appendix 5).

Cigarette craving was measured by averaging the two single items, "I have a desire for a cigarette right now" and "strength of desire to smoke right now" using a 7-point scale (1 = strongly disagree, 4 = neither agree nor disagree, 7 = strongly disagree), which has acceptable validity and reliability (Tiffany & Drobes, 1991) and sensitivity to change following exercise (Daniel et al., 2004; Ussher et al., 2001). Cronbach's alpha was ranged from .82 to .96 ensuring high reliability.

Urges to smoke were assessed using the 32-item Questionnaire on Smoking Urges (QSU; Tiffany & Drobes, 1991) on a 7-point scale (1 = strongly disagree, 4 = neither agree nor disagree, 7 = strongly disagree) (see Appendix 6). This questionnaire assesses two

manifestations of smoking urges: intention and desire to engage in smoking behaviour which is anticipated as pleasant, enjoyable and satisfying (desire-behave), and anticipation of relief from negative affect through smoking (desire-affect relief). According to Tiffany and Drobes (1991), both manifestations (desire-behave and desire-affect relief) co-exist and they argue that conceptualizations emphasizing only drug appetite effect or drug withdrawal and negative affect, in the generation of smoking urges, may be incomplete. Items were scored as outlined by Tiffany and Drobes (1991). According to Tiffany and Drobes (1991), the scoring of the QSU is based on their factor analysis of scores from a group of 230 smokers. Fourteen of the 32 items were reversed keyed in order to reduce variance due to acquiescence. Prior to the analysis of the data in this study the items were reversed. Fifteen items contribute to scores on desire-behave, which reflects the desire to smoke and the anticipation of positive outcomes and intention to smoke, and 11 items contribute to desire-affect-relief, which reflects anticipation of relief and a strong urge to smoke. The remaining six items do not contribute to the scoring.

Tension and energy were measured using single items from the Mood and Physical Symptoms Scale (MPSS) (West & Hajek, 2004). The original 5-point scale (1 = not at all, 3 = somewhat, 5 = extremely) in response to the question, "How do you feel right now?" was used. Multi-item measures of tension and vigor were taken from the 37-item version of the POMS (Shacham, 1983).

Affective valence and activation were assessed using the 11-point, from -5 to +5 feeling Scale (FS; Hardy & Rejeski, 1989) (see Appendix 7) and a modified 6-point version, from 1 to 6, of the Felt Arousal Scale (FAS; Svebak & Murgatroyd, 1985) (see appendix 8), which targets basic affect as a dimensional circumplex model of affect (Russell, 1980).

The FAS was modified to ensure consistency of responses with the FS scale and maximize the range and distribution of responses. As a domain-generic measure of basic affect, it is based on both a strong theoretical and empirical rationale (Ekkekakis & Petruzzello, 2002). The generic nature of the measure takes on more importance given the dual context of smoking abstinence and cravings and exercise. It has not been used in the smoking context to consider affective response to abstinence. See appendices 9 and 10 for instructions on how to score the FS, FAS and Borg scales at the exercise session and how to score on the FS and the FAS on the control session, respectively.

### **3. 1.3(1) Administration**

Instructions were given upon arrival at the laboratory after the participants had been informed about the nature of the study and had signed the informed consent. The items 'desire to smoke', 'strength of desire to smoke', the MPSS and the circumplex model were administered at five measurement times: prior to (time 1), at mid-point of (time 2), immediately after (time 3), then at 10 minutes (time 4) and 20 minutes (time 5) post treatment. The POMS and the QSU were administered only at baseline (time 1) and at 20 minutes (time 5) post-treatment because of the time needed for administration and concern that a lengthy survey may serve as a prompt for smoking urges.

## 3. 2 Results

### *Preliminary analyses*

The participants' baseline characteristics were as follows: mean FTND score, 4.0 (SD = 3.1); mean expired air CO (ppm) following abstinence, 6.4 (SD = 2.6); mean time doing moderate or vigorous physical activity, 398.7 (SD = 247.8) min/week. The mean self-selected intensity of walking was equivalent to a light-intensity heart rate reserve of 24.5% (SD = 7.6, range 12.1– 41.5) and an RPE rating of 10.8 (SD = 1.49, fairly light, range 7.1– 12). (A mean resting heart rate during the passive condition was used to determine heart rate reserve; ACSM, 2000). Walking one mile took on average 17.8 minutes (SD=2.8), ranging from 15 to 23 minutes and 20 sec. Table 3.1 shows the mean and standard deviation for the 2 manifestations of the QSU (standardized for the number of items in each scale), cravings, tension (as assessed by the MPSS and the POMS), energy, vigor, affective valence and affective activation throughout the study.

TIME		0 min $\bar{x}$ (SD)	10 min $\bar{x}$ (SD)	20 min $\bar{x}$ (SD)	30 min $\bar{x}$ (SD)	40 min $\bar{x}$ (SD)
QSU: Desire-behave	Control	5.5 (1.2)				5.4 (1.4)
	Exercise	5.9 (1.2)				3.9 (1.1)
QSU: Desire-affect relief	Control	4.2 (1.1)				4.3 (1.1)
	Exercise	4.8 (1.0)				3.2 (1.3)
Cravings	Control	5.4 (1.6)	5.1 (1.2)	5.7 (1.1)	5.1 (1.2)	5.9 (1.2)
	Exercise	5.5 (1.5)	1.1 ( .9)	1.0 ( .5)	1.5 ( .9)	2.5 (1.6)
MPSS						
Tension	Control	2.9 ( .8)	2.9 ( .8)	2.8 (1.1)	2.9 (1.1)	2.9 (1.2)
	Exercise	3.7 (1.1)	1.7 ( .7)	1.3 ( .5)	1.1 ( .3)	1.3 ( .6)
Energy	Control	1.7 ( .8)	1.9 ( .8)	2.0 (1.2)	2.1 (1.4)	2.0 (1.2)
	Exercise	1.3 ( .8)	2.2 (1.0)	2.3 ( .8)	1.9 (1.1)	1.9 ( .9)
POMS						
Tension	Control	10.8 (4.5)				9.7 (4.6)
	Exercise	13.6 (4.9)				4.1 (4.4)
Vigor	Control	4.1 (3.3)				4.3 (4.1)
	Exercise	3.2 (2.3)				5.5 (4.2)
AFFECT						
Affective valence	Control	7.3 (1.4)	6.9 (1.5)	6.9 (1.7)	6.7 (1.8)	6.5 ( .5)
	Exercise	6.2 (2.1)	7.6 (1.7)	9.1 (1.6)	8.8 (1.7)	8.9 (1.5)
Affective activation	Control	6.1 (1.8)	6.7 (1.9)	6.8 (2.0)	7.5 (1.8)	6.6 (2.5)
	exercise	5.9 (1.2)	7.9 (1.9)	8.8 (1.7)	6.9 (1.7)	7.4 (1.8)

Note: Exercise took place between 0-20 minutes.

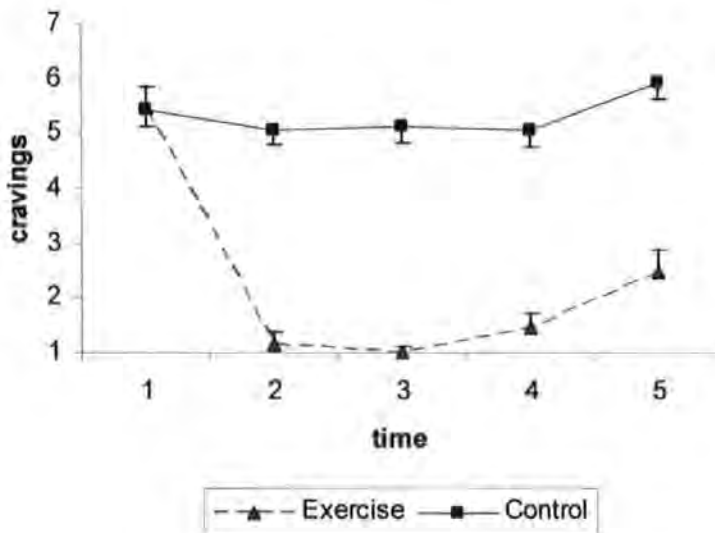
**Table 3.1:** Mean  $\bar{x}$  (SD) for craving, the two manifestations of the QSU, mood and affect for sessions involving the Control and Exercise Conditions.

There were no significant differences in baseline scores between the respective conditions on each of the variables, although there was a trend toward tension (MPSS and POMS) being greater prior to exercise (but that was not statistically significant). ANCOVAs with exercise (exercise, control) as a between participants factor (all at baseline) and type of variable as a within subject factor (all at baseline) and order of treatment as covariate, revealed that order of treatment had no influence on the effects of exercise on cigarette cravings or other outcome measures,  $F(17, 221) = 1.07, p > .05$ , effect size Cohen's  $d = .14$ .

### **3. 2.1. The effects of exercise on cravings, urges to smoke, mood and affect**

To examine hypothesis 1 (a) concerning effects of exercise on cravings and urges to smoke, a 2 (exercise: walking, passive) x 2 (cravings: time1, time5) x 2 (desire-affect-relief: time1, time 5) x 2 (desire-behave: time1, time 5) MANOVA was performed. The omnibus MANOVA revealed a significant overall interaction effect of exercise by time, Wilk's  $\lambda = .24, p < .01, F(1, 14) = 45.60, p < .01$ , effect size, Cohen's  $d = 2.5$ . Separate univariate ANOVAs, revealed significant interaction effects for urges to smoke: desire-behave,  $F(1, 14) = 18.50; p < .01$  and desire-affect relief,  $F(1, 14) = 35.60, p < .01$ . While a 2 (exercise: walking, passive) x 5 (cravings: time1, time2, time3, time4, time5) analysis revealed exercise x time interactions for cravings,  $F(4, 11) = 27.50, p < .01$  (see Figure 3.1). In each case, planned contrasts revealed that the exercise condition scores were significantly lower at follow-up, compared with baseline. Effect sizes (Cohen's  $d$ ) were 1.3, 1.0 and 1.9, for desire-behave, desire-affect relief, and cravings respectively. The same analysis 2 (exercise: walking, passive) x 2 (cravings: time1, time5) x 2 (desire-affect-relief: time1, time 5) x 2 (desire-behave: time1, time 5) for cravings and urges was

also conducted with the addition of number cigarettes smoked daily and levels of physical activity and number of cigarettes smoked daily as covariates. Results of the ANCOVAs did not revealed significant interaction effects for number of cigarette smoked for cravings  $F(1, 14) = 0.31, p = .87$  and partial  $\eta^2$  values decreased considerably from .06 to .04. Neither for urges to smoke: desire– behave  $F(1, 13) = .06, p = .82$  and partial  $\eta^2$  values decreased considerably from .06 to .04; desire–affect relief  $F(1, 13) = .01, p = .93$  and partial  $\eta^2$  values decreased considerably from .03 to .01. These findings are indicating that the previous smoking status of the participants could control the effects of exercise on cravings and the two manifestations of urges to smoke. When controlling for levels of physical activity significant interaction effects were still observed and therefore one can conclude that previous levels of physical activity are not responsible for the effects of exercise on cravings and urges to smoke.



**Figure 3.1:** *Cravings for exercise and control conditions.*

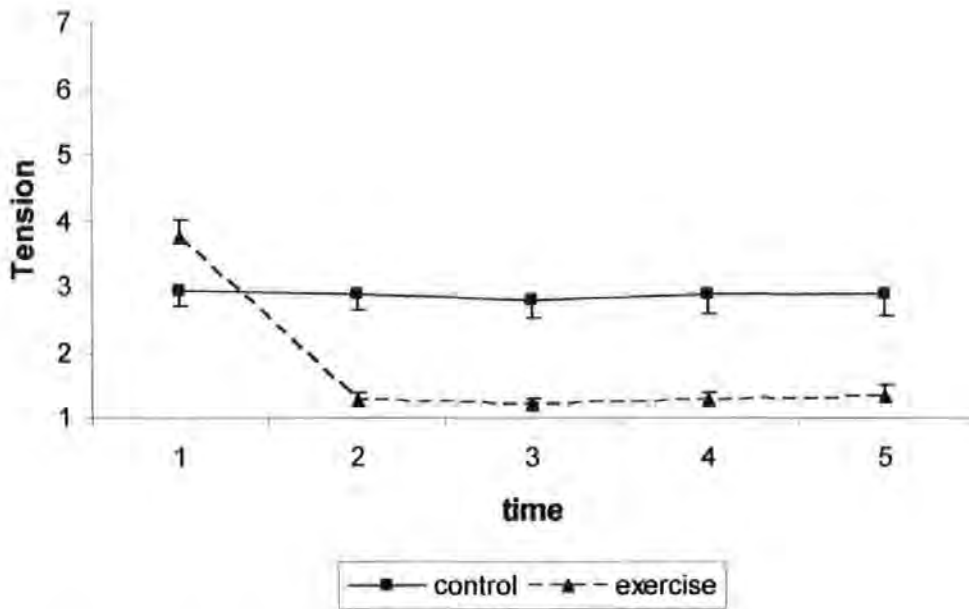
*Note: time = 1 Baseline, time 2 = 10 minutes during the exercise, time 3 =end of exercise session, time 4 = 10 minutes following exercise, time 5 = 20 minutes following exercise.*

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To examine hypothesis 1 (b), the effects of exercise on mood (as measured by the MPSS), a repeated-measures 2 (exercise: walking, passive) x 5 (tension, single item: time1, time2, time3, time 4, time 5) x 5 (energy: time1, time2, time3, time 4, time 5) MANOVA was conducted. Results from the MANOVA revealed a statistically significant overall time -by- exercise interaction, Wilks'  $\lambda = 0.33$ ,  $F(4, 56) = 7.30$ ,  $p < .01$  (Cohen's  $d = 1.0$ ) as well as a 3 way interaction between exercise, tension and energy, Wilks'  $\lambda = .18$ ,  $F(4, 56) = 15.20$ ,  $p < .01$ , (Cohen's  $d = 1.4$ ) and as hypothesized a 2-way interaction between exercise and tension (figure 3.2),  $F(4, 56) = 19.60$ ,  $p < .01$ , Cohen's  $d = 1.6$ .

Planned contrasts (with Bonferroni adjustment for multiple comparisons) revealed that exercisers reported lower levels of tension at all points of measurement than participants in the control group ( $ps < .05$ ). Although there was no statistically significant 2-way interaction between exercise and energy, planned contrasts did reveal a trend toward higher energy at mid- ( $p = .05$ ) and end of exercise ( $p = .08$ ) among exercisers compared with participants in the control condition. Given that the 3-way interaction between exercise, tension and energy was not hypothesized, it was not analyzed further.





**Figure 3.2:** Tension levels (as measured from the MPSS) for exercise and control conditions.

*Note: time = 1 Baseline, time 2 = 10 minutes during the exercise, time 3 =end of exercise session, time 4 = 10 minutes following exercise, time 5 = 20 minutes following exercise.*

To examine the effects of exercise on multi-item measures of tension and vigor, a 2 (exercise: walking, passive) x 2 (tension: time1, time 5) x 2 (vigor: time1, time 5) MANOVA was conducted with all factors used as a within participant factors. Result revealed a statistically significant multivariate effect, Wilks'  $\lambda = .65$ ,  $F(1, 14) = 7.50$ ,  $p < .05$  (effect size Cohen  $d = 1.0$ ), as well as a 3 way interaction between exercise, tension and vigor, Wilks'  $\lambda = .37$ ,  $F(1, 14) = 23.40$ ,  $p < .01$ , (Cohen's  $d = 1.0$ ) and a 2-way interaction between exercise and tension,  $F(1, 14) = 21.80$ ,  $p < .01$ , effect size for tension (Cohen's  $d = 1.7$ ). Planned contrasts (with Bonferroni adjustment for multiple comparisons) revealed that exercisers reported lower levels of tension at all points of measurement than participants in the control group ( $ps < .01$ ).

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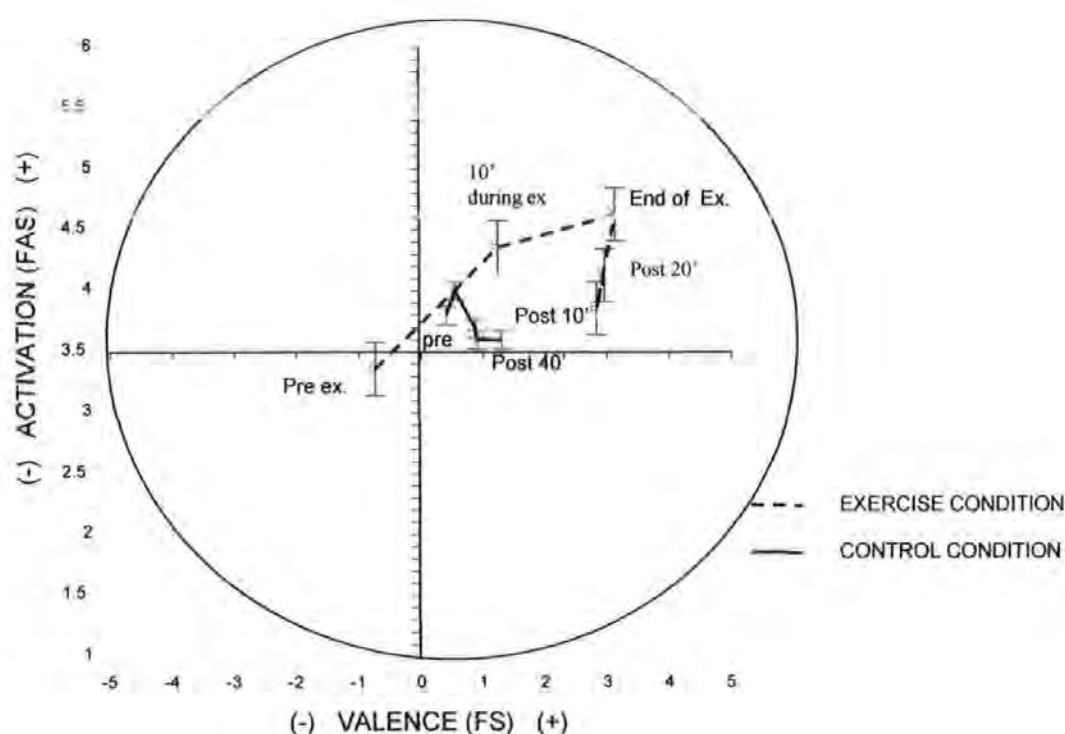
The same analyses 2 (exercise: walking, passive) x 5 (tension, single item: time1, time2, time3, time 4, time 5) x 5 (energy: time1, time2, time3, time 4, time 5) and 2 (exercise: walking, passive) x 2 (tension: time1, time 5) x 2 (vigor: time1, time 5) were also conducted with the addition of number cigarettes smoked daily and levels of physical activity and number of cigarettes smoked daily as covariates. Results of the ANCOVAs did not revealed significant interaction effects for number of cigarette smoked for tension (single item, multiple item): tension (single item)  $F(4,10) = 2.50$ ,  $p = .11$  and partial  $\eta^2$  values decreased considerably from .26 to .01; tension (POMS),  $F(1,13) = 2.37$ ,  $p = 1.48$  and partial  $\eta^2$  values decreased considerably from .15 to .09; energy  $F(4, 10) = 0.19$ ,  $p = .94$  and partial  $\eta^2$  values decreased considerably from .10 to .07; and vigor  $F(1,13) = 4.14$ ,  $p = .06$  and partial  $\eta^2$  values decreased considerably from .08 to .04. When controlling for levels of physical activity significant interaction effects were still observed and therefore one can conclude that previous levels of physical activity are not responsible for the effects of exercise on mood indices.

To test the hypothesis 1 (c), the effects of exercise on affect were investigated through a 2 (exercise: walking, passive) x 5 (activation: time1, tme2, time3, time4, time5) x 5 (valence: time1, tme2, time3, time4, time5) MANOVA. Results revealed a statistically significant multivariate effect of exercise by time, Wilks'  $\lambda = .26$ ,  $F(4, 56) = 5.5$ ,  $p < .01$  (Effect size, Cohen's  $d = .9$ ), and a 3-way interaction between exercise, valence and activation, Wilks'  $\lambda = .29$ ,  $F(4, 56) = 6.12$ ,  $p < .01$  (Effect size, Cohen's  $d = .9$ ). Separate univariate ANOVAs revealed significant time-by-exercise interaction effects for activation,  $F(4, 56) = 4.0$ ,  $p < .01$  (Effect size, Cohen's  $d = .7$ ), and valence,  $F(4, 56) = 7.1$ ,  $p < .00$  (Cohen's  $d = .9$ ).

Planned contrasts (with Bonferroni adjustment for multiple comparisons) revealed statistically significantly ( $p < .01$ ) higher levels of activation only at the end of exercise (time 3) compared with the control condition, as well as statistically significantly ( $p < .01$ ) higher valence at the end of exercise (time 3) and at 10 minutes (time 4) and 20 minutes (time 5) post- exercise. Figure 3.3 (shown overleaf), displays changes in valence and activation, within the two-dimensional affective space of the circumplex model, for the exercise and passive (control) conditions, over five assessments.

When conducting a 2 (exercise: walking, passive) x 5 (activation: time1, time2, time3, time4, time5) x 5 (valence: time1, time2, time3, time4, time5) analysis with number of cigarettes smoked daily and levels of physical activity as covariates results of the ANCOVAs revealed significant interaction for affective valence and activation when controlling for number of cigarette smoked. Affective valence:  $F(4, 10) = 0.78, p = .56$  and partial  $\eta^2$  values decreased considerably from .08 to .04. Affective activation:  $F(4, 10) = .40, p = .81$  and partial  $\eta^2$  values decreased from .18 to .16. Affective activation:  $F(4, 10) = .40, p = .81$  and partial  $\eta^2$  values decreased considerably from .65 to .28.

ANOVAs with levels of physical activity as covariate revealed significant interaction effects and therefore one can conclude that those levels of physical activity are not responsible for the effects of exercise on affect.



**Figure 3.3:** *Circumplex model: Two-dimensional representation of affective responses defined by changes in Valence (FS scale) and Activation (FAS scale).*

Overall, in support to hypothesis 1, results showed that exercise reduced levels of cravings and urges in comparison to the control condition and the effects lasted for at least 20 minutes following exercise. In addition, walking reduced tension (as measured by both single and multiple item measures) during exercise and for at least 20 minutes after exercise. There were not any significant effects of exercise on energy and vigor ( $ps > .05$ ). Furthermore, walking resulted in an increase in affective activation only up to the end of the exercise (time 3), and an increase in affective valence during and for at least 20 minutes post exercise (time 5).

### **3. 2.2. Mediating effects of mood and affect on the effect of exercise on cravings and urges**

To examine hypothesis 2 concerning mediating effects of mood and affect on cravings and urges to smoke a series of ANCOVAs were conducted. The decision to use ANCOVAs in order to test mediation followed after consideration of three issues. First, the criteria set out by Baron and Kenny (1986) to test mediation effects did not apply in the present study. A regression model although it can be used in between-participants designs, in the present study treatment comparisons involved a within-participant design (Judd, Kenny & McClelland, 2001). Second, the large-sample assumptions underlying some estimation procedures used in multilevel modeling was untenable in the present study (Judd et al., 2001). Third, in addiction literature a number of authors have tested mediation with the use of ANCOVAs (Bock, 1975; Dallery, Houtsmuller, Pickworth & Stitzer, 2003; Gross & Stitzer, 1989; Goff, Henderson & Amico, 1992; Koski-Jännes & Turner, 1999; Okubo, Miyamoto, Suwazono, Kobayashi & Nogawa, 2002; Shiffman, Dresler, Hajek, Gilbert, Targett & Strahs, 2002; Valimaki, Karkkainen, Lamberg-Allardt, Laitinen, Alhava, Heikkinen et al. 1994; Woolf, 1999). Therefore, the use ANCOVAs in the present study aims to integrate the present research with the relevant literature.

One ANCOVA used a 2 (exercise: walking, passive) x 5 (cravings: time 1, time 2, time 3, time 4, Time5) design and used the change scores (from baseline to follow-up at 20 minutes post-treatment) of tension (both the single and multi item), energy, vigor, affective valence and affective activation, as covariates. The second ANCOVA has a 2 (exercise: walking, passive) x 2 (desire-affect-relief: time 1, time5) x 2 (desire-behave: time1, time 5) design and the same covariates. Results from these analyses revealed mediating effects of tension (as measured by both, single and multiple items) on urges and Cravings.

With tension (single item) as the covariate, there was no significant interaction effect for cravings and the 2 manifestations of urges to smoke. For cravings,  $F(4, 10) = 2.31, p = 1.30$  partial  $\eta^2$  values decreased considerably from .90 to .48. For urges to smoke: desire-behave,  $F(1, 13) = .48, p = .50$ , partial  $\eta^2$  values decreased considerably from .57 to .03; and desire-affect-relief,  $F(1, 13) = 3.8, p = .07$ , and partial  $\eta^2$  values decreased considerably from .72 to .22.

With tension (multiple items) as the covariate there were also no significant interaction effect for cravings,  $F(4, 10) = 3.44, p = .06$ , partial  $\eta^2$  values decreased considerably from .90 to .58. There were also no significant interaction effects for the 2 manifestations of urges to smoke: desire-behave:  $F(1, 13) = 3.11, p = .10$ , partial  $\eta^2$  values decreased considerably from .57 to .19; and desire-affect-relief,  $F(1, 13) = .25, p = .63$ , partial  $\eta^2$  values decreased considerably from .72 to .02.

With affective activation (as measured by the circumplex model) as the covariate although there was a significant interaction effect for cravings,  $F(4, 10) = .44, p = .07$  partial  $\eta^2$  values decreased considerably from .57 to .03, there was no significant interaction effects for the 2 manifestations of urges to smoke: desire- affect,  $F(1, 13) = 1.8, p = .21$ ; partial  $\eta^2$  values decreased considerably from .82 to .69, and desire-affect-relief,  $F(1, 13) = 1.88, p = .19$ , partial  $\eta^2$  values decreased considerably from .82 to .12.

With vigor, energy and affective valence as covariates significant treatment effects were still observed, and one can conclude that these variables are not responsible for mediating the effects of exercise on cravings and urges. In summary, partly supporting hypothesis 2,

only changes in tension and affective activation mediated the effects of exercise on cravings and urges to smoke.

***Additional analysis: Relationships between Cravings and Affect***

Although it was not the scope of the present investigation, in order to examine the relationship between cravings mood, and affect, both cross-sectionally and in terms of change in response to the treatment, we conducted several analyses. Cross-sectional correlations between cravings, mood and affect measures were calculated, using pre- and 20-minutes post-exercise data. Also change scores (between pre- and 20-minutes post exercise) were calculated and correlations between these scores were determined. Cross-sectional correlations between cravings mood and affect, both prior to and 20 minutes post exercise, are shown in Table 3.2. The table also shows correlations between calculated change in cravings and affect, between baseline and 20 minutes post exercise. At baseline, cravings were associated with higher scores for tension (MPSS and POMS) and a lower energy score (MPSS). At 20 minutes post exercise cravings were associated with higher tension scores (MPSS item). Reductions in levels of cravings were associated with reductions in levels of tension (MPSS items) between baseline and 20 minutes post-exercise. Urges to smoke were not correlated with affect and mood, only desire-affect-relief was correlated with tension (both single and multiple items) at baseline.

	Correlations between cravings and mood/affect (at T1)	Correlations cravings and mood/affect (at T5)	Correlations between change in cravings and change in mood/affect (from T1-T5)
<b>MPSS items</b>			
Tension	.84**	.59**	.84***
Energy	-.57*	.24	-.50
<b>POMS scales</b>			
Tension	.70**	-.51	.47
Vigor	-.51*	.04	-.07
<b>Circumplex affect</b>			
Valence	-.32	-.05	.07
Activation	-.58	.24	.03

**Table 3.2:** Cross-sectional and change (from T1-T5) correlations between cravings, mood and affect. \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$ .

Notes: T1 = Baseline, T5= 20 minutes post exercise.

### 3. 3. Discussion

The results of the study clearly show that following a 15-hour smoking abstinence, walking for a mile (or for approximately 17-20 minutes), with some degree of control over intensity, reduced levels of cravings, urges to smoke, mood and affect. The effects of exercise on cravings were mediated by reductions in tension. Furthermore, the effects lasted for at least 20 minutes following the exercise. This is the first study to show the positive effects of low intensity exercise on urges to smoke, mood and affect and the duration of these effects lasting beyond the period of exercise.



The first prediction of hypothesis 1 (a) was that exercise would reduce cravings and urges to smoke and the effects will last for at least 20 minutes following exercise. Cravings and urges were measured using single and multiple item measures, which is a unique contribution of study 1. In support of hypothesis 1 (a) results of the study showed that exercise reduced levels of cravings.

The effects of exercise on cravings were supported by both the single and multiple item measures. This finding compares favourably with previous research that has demonstrated that exercise reduces cravings and urges to smoke and that the effects of exercise lasted for at least 10 minutes following the exercise (Bock et al., 1999; Daniel et al., 2006; Daniel et al., 2004; Everson et al., 2006; Pomerleau et al., 1978; Thayer et al., 1993; Ussher et al., 2001, 2006). Moreover, extending findings of previous studies, the effects of exercise on cravings in this study were also supported by multiple item measures, which provide greater reliability for the findings of previous studies that used only single item measures (Bock et al., 1999; Daniel et al., 2006; Daniel et al., 2004; Everson et al., 2006; Pomerleau et al., 1978; Thayer et al., 1993; Ussher et al., 2001, 2006). It was also shown that exercise reduced levels of cravings and urges and that the effects lasted for at least 20 minutes following exercise, which add to the length of possible effects. The effect size (even at 20 minutes post-exercise) for cravings (Cohen's  $d = 1.90$ ) was larger than previously reported by Daniel et al., (2004) and Ussher et al., (2001) at any time point in their studies. In the study by Ussher et al., (2001) the effect sizes (Cohen's  $ds$ ) for the exercise vs. rest condition were equal to .78, .90, .87 and .76 during, post, 5 minutes post- and 10 minutes post-treatment, respectively. In the study by Daniel et al., (2004) the effect sizes (Cohen's  $ds$ ) for the moderate-intensity exercise vs. rest condition were equal to .54, .47, .27 and .14, during, post, 5 minutes post- and at 10 minutes post-treatment, respectively.

Given the evidence that smoking could act as a stimulus and relaxant (see Parrott, 1998, for a review) another scope of study 1 was to examine whether exercise could mimic the effects of exercise by inducing feeling of relaxation and activation (known as Nesbitt's paradox). More specifically, hypothesis 1 (b), examined the fact that exercise could act as a stimulus mimicking the effects of smoking by inducing relaxation (reduced tension) and activation (increased energy and vigor). In order to examine the relaxing and activating properties of exercise, single and multiple items of tension and activation were used. The results of the study compared favourably with previous research (Daniel et al., 2006; Daniel et al., 2004; Everson et al., 2006; Ussher et al., 2001, 2006) that has demonstrated, using single item measures, that exercise reduces tension and the effects lasted for at least 10 minutes following exercise. Extending their findings, results of study 1 indicated that the effects of exercise on tension were also supported by multiple item measures, which provides greater external validity for their findings. Furthermore, in this study the effects of exercise on tension lasted for at least 20 minutes following exercise, which extends the length of duration of possible effects.

Unexpectedly there were not any statistically significant effects of exercise on energy and vigor. This may have been due to several reasons. First, the sample size of the study was small. Second, exercise and the laboratory setting might have elevated levels of arousal among smokers thereby making detection of exercise affect difficult. Third, the specific measures of mood may have not captured exercise induced arousal. Therefore exercise could mimic the effects of smoking by inducing relaxation.

Overall, in partial support of hypothesis 1 (b), the results of the study indicated that exercise reduces tension and the effects lasted for at least 20 minutes following exercise.

Hypothesis 1 (c) predicted that exercise would reduce affective valence and increase affective activation and the effects would last for at least 20 minutes following exercise. The effects on valence and activation were measured through the circumplex model of affect, which examines valence and activation independently and at the same time. This is important as it can disentangle changes in activation from changes in affective valence (Ekkekakis and Petruzzello, 2002). Failing to distinguish changes along the activation dimension from changes along the valence activation may lead to misleading findings (Ekkekakis & Petruzzello, 2000). In support of hypothesis 1(c) the results of the circumplex model showed that exercise reduced affective valence (relaxation) and induced affective activation.

The graphical representation (figure 3.3) of affective responses on the circumplex space clearly demonstrated that a short bout of walking was associated with significant, often substantial, shifts towards higher activation and a more pleasant affect. Assessments of affect following the recovery period (20 minutes) showed that although affective valence remains high, the energising effects associated with walking tend to be short lived. During the recovery period the pattern of increased valence and the gradually decreasing levels of activation suggested that participants were experiencing a state of calmness and relaxation. This finding supports previous findings by Ekkekakis et al. (2000), who showed that short walks (10-15 minutes) were associated with increases towards activation and more positive affective valence in non-smokers. Their results also indicated that a 10-15 minute recovery from walking was associated with a return towards calmness and relaxation. This pattern reported by Ekkekakis et al. was robust across different self-report measures of the circumplex affective dimensions, across different ecological settings (field and laboratory), across time, and across samples.

The findings of the circumplex model in Study 1 are important because they demonstrate that exercise reduced stress. More importantly, findings clearly showed that exercise has a dual effect on activation. It increases activation, lasting until the end of exercise, following which; activation is reduced resulting in a feeling of calmness. When people are in a state of calmness then they are less reactive to stressors, and therefore are less likely to smoke. In support to this finding Schachter (1978) noted: "smokers widely report that they smoke more when they are tense or anxious and they also report that smoking calms them" (p. 209). Conclusively, the findings of the circumplex model in this study suggest that following exercise previously deprived, smokers are experiencing a level of calmness and relaxation which protects them from smoking.

Hypothesis 2 suggested that the specific moods of tension, vigor and energy, as well as affective valence and activation, will mediate the effects of exercise on cravings and urges to smoke.

In partial support of hypothesis 2, ANCOVAs, in Study 1, suggested that reductions in cravings were mediated by reduced tension (emotional stress) while effects on urges were mediated by affective activation (calmness). Increased energy, vigor (stimulation), or affective valence did not mediate cravings and urges. This is the first study to examine the mediating effects of mood on urges and to reveal such an effect. This finding has some important implications; it suggests that symptoms of stress (i.e., tension) can be reduced through exercising and will in turn be associated with reduced cravings for a cigarette. Stress has been associated with smoking relapse (Cohen & Lichenstein, 1990). Further research is needed to determine whether exercise can attenuate increased cravings in response to situational cues, by reducing stress and its symptoms.

### Chapter 3: Study 1

Overall, Study 1 contributes to the extant literature by documenting that exercise has an acute positive effect on urges to smoke, mood and affect. Similar effects observed for single- and multiple-item measures supported reliability and external validity for Study 1. In addition the within-subject design implemented by Study 1 supports the effects of exercise on urges to smoke, mood and affect at the intra-individual level of analysis.

Additional ANCOVAs controlling for participant's previous levels of physical activity and number of cigarette smoked indicated that the previous smoking status of the participants could mediate the effects of exercise on mood, affect, levels of cravings and urges. In the present study participants were moderate smokers smoking on average 16.6 cigarettes daily, future studies are needed in order to investigate further the effects of exercise in heavy and light smokers

This is the first study to show the positive effects of low intensity exercise on urges to smoke, mood and affect lasting beyond the period of exercise, and for 20 minutes post-treatment. A unique contribution of study 1 is the exploration of the mechanisms responsible for the exercise effects. The results of the study suggested that exercise could mimic the pleasurable effects of smoking by effecting activation and stress.

Most critical; by focusing on self-paced moderate intensity walking and by following smoking behavior of relatively active individuals for 20 minutes post-exercise, the present study points out that the effects of exercise on urges to smoke generalise to active populations and across different types of physical activity.

## **Chapter 4**

### **4. Study 2**

#### **4. 0 Introduction**

Results from Study 1 indicated that moderate intensity exercise (walking) can reduce absolute levels of cravings and mood and affect for up to 20 minutes (Taylor et al., 2005), compared with a passive condition. Further, the effects of exercise on cravings appear to be partly mediated by changes in affective responses, specifically reduced tension. Although findings of Study 1 advance knowledge in the area of exercise and smoking cessation there are still some limitations that need to be addressed.

First, the treatment effects were only observed for up to 20 minutes after exercise, and during these 20 minutes participants remained in a laboratory under controlled conditions. The observed effects were not evaluated in the natural environment when participants were allowed the freedom to smoke. Second, it is unknown if exercise attenuates any increases on cravings under conditions which would normally increase cravings, such as stress or the present of smoking cues such as a lit cigarette. No study has yet examined if a single session of exercise is useful for regulation of stress and cue-elicited cravings and withdrawal symptoms. Third, studies may have involved experimenter bias since the condition in which participants took part in was known to the researcher during post-treatment follow-up assessments. Fourth, previous well-controlled studies, including study 1, have required about 15 hours of smoking abstinence to elevate urges to smoke prior to

exercising, in a protocol designed to simulate quit attempts. It is not known what the size of effects would be following briefer abstinence, such as two to four hours, when many moderate smokers may begin to experience the urge to smoke. Fifth, walking as the most common and convenient form of exercise has only been investigated in Study 1 but the duration was poorly controlled, varying from 17 to 23 minutes on the self-paced one-mile walk. Finally, only one published study by Thayer et al., (1993) measured the time it took the participants to smoke their next cigarette after the exercise session, but the study had limitations such as an unclear dose of exercise and an uncontrolled experimental environment. Therefore, more controlled studies are needed to examine the duration of the exercise effects after people leave the laboratory and are exposed to a natural environment where they have the freedom to smoke.

### **4. 0.1. Aims and Hypotheses**

The purpose of the present study was to address these issues. In this study participants were smoking abstinent for two hours. Specifically, by adopting a between participants blind design, Study 2 aimed to determine whether a 15-minute walk at partly self- preferred intensity would reduce withdrawal symptom and cravings, and whether any effects would be maintained during the subsequent presentation of stressors and cues all previously used to successfully elicit an urge to smoke. Also, the present study aimed to determine whether the self-paced walk would extend the time to ad libitum smoking, and if this time would be predicted by cigarette cravings at the end of experimental procedures.

The present study will test the following hypotheses:

***Hypothesis 3:*** A self-paced 15 minute walk will reduce cravings and withdrawal symptoms in comparison to the control condition. Further, exercise will attenuate

increases in cue-elicited cravings and withdrawal symptoms in comparison to the passive control group.

**Hypothesis 4:** The time participants have their next ad libitum cigarette, after leaving the laboratory, will be extended following exercise. Furthermore, cravings measures will be negatively associated with time to smoking the next cigarette.

## **4.1 Materials and methods**

### **4.1.1. Participants and procedures**

Following ethical approval from the University Research Ethics Committee, smokers were recruited through public advertisements and personal communication with the researcher. They were eligible for the study if there were no contraindications for moderate intensity exercise, were not pregnant, and not receiving any psychiatric treatment and had smoked at least 10 cigarettes daily for the past three years. Participants provided informed consent and were asked to abstain from smoking, caffeine intake and exercise for two hours prior to the visit to the laboratory. The limit to two hours of abstinence was necessary to avoid high baseline cravings that may lead to a ceiling effect when conducting a cue-eliciting craving study (Carter & Tiffany, 1999; Schuh & Stitzer, 1995). They were also asked to bring a packet of their favourite cigarette brand and a mobile phone to the session.

Upon arrival at the laboratory, participants were given verbal and written information about the study and then they provided informed consent (Appendix 11). They also completed a medical questionnaire to ensure that they were fit to undertake physical activity (see appendix 2). Expired carbon monoxide (CO) levels were used to confirm abstinence (<15ppm) upon arrival at the testing (Bedfont Smokerlyzer). Measures of weight, height,



resting heart rate and systolic and diastolic blood pressure (SBP/DBP) (Digital BP Monitor Model UA-767PC, A & D Instruments) were taken, and body mass index (BMI) was calculated, to provide descriptive data for the sample. Self-reported nicotine dependence was assessed using the Fagerström Test for Nicotine Dependence: FTND (Heatherton et al., 1991) (see Appendix 4). Physical activity was assessed using the self-report 7-day recall measure, which has been shown to have acceptable validity and reliability (Blair et al., 1985) (see Appendix 5).

Three participants were excluded from the study due to receiving psychiatric treatment and one due to not completing the experiment.

Participants were then fitted with a heart rate monitor (Advantage, POLAR) and taken into a room with an exercise treadmill and a trained research assistant, who was not familiar with the overall purpose of the study. Sixty participants were randomly assigned to either an exercise ( $n = 31$ ) or passive ( $n = 29$ ) group by the research assistant who then supervised the treatment session.

### **4. 1.2. Treatment**

*Exercise condition:* This consisted of a two minute warm-up at 4km/hr, followed by a 15 minute flat walk on a treadmill at a semi-preferred intensity, and two minute cool down at 4km/hr. We describe it as semi-preferred since participants were instructed to walk briskly for 15 minutes (as if they were late for an important appointment but not to the point of breathlessness) but had some control over the intensity. During the walk participants could request a faster or slower pace. The research assistant modified the treadmill speed as requested by the participants but engaged in minimal verbal dialogue. To determine exercise intensity a Rating of Perceived Exertion (RPE) using the 6-20 Borg scale (Borg,

1998) was recorded every two minutes together with continuous heart rate. The mean (standard deviation) exercise intensity for walkers was subsequently calculated: Heart Rate Reserve = 24.1% (5.1); RPE = 10.9 (1.4) (i.e., 'fairly light').

*Passive condition:* This took place in the same exercise facility. Participants were asked to sit quietly and were spoken to only when craving and withdrawal symptom measures were administered. Participants were not asked about RPE. The decision to use a passive control condition in the exercise laboratory followed careful consideration of previous studies. First, Ussher et al., (2001) and Daniel et al., (2006) both concluded that exercise reduced cravings and withdrawal symptoms even when compared with a distracting task. Second, the duration of reduced cravings (20 minutes) as shown in Study 1 would suggest that distraction is not the main mechanism (Taylor et al., 2005). Thirdly, the same passive conditions have been shown to produce stable reporting of cravings and withdrawal symptoms.

Ten minutes after the treatment session participants were taken to the second experimenter, (who was blind to the experimental condition) in an adjacent room. Few studies designed to investigate the acute effects of exercise on subjective responses have involved such a blind procedure to avoid confounding from researcher expectancy. Participants then underwent further assessments prior to and after two stressors, the stroop and speech task (task 1 and 2 respectively), presented in random order, with a 10 minute rest period between tasks. Finally, after a further 10 minutes of sitting quietly alone participants were presented with a smoking cue (lit cigarette) (task 3). The third cue was presented last because it has been shown to increase in potency as time passes following the previous cigarette (Al'Absi et al., 2002), and this was planned to be at least three hours since the last cigarette.

***Post-treatment***

***Stressor 1 (task 1):*** A three minute computerized version of the Stroop word-colour interference task was administered which affects physiological and emotional arousal (Renaud & Blondin, 1997). It has been commonly used to study the acute effects of exercise on psycho-physiological reactivity in the acute exercise context (Hamer et al., 2005), and as a cognitive challenge among smokers (Powell, Tait & Lessiter, 2002). Each second, the word of a colour was presented in letters of compatible or incompatible colour, and participants were required to verbally state the colour of the word. The researcher recorded all responses.

***Stressor 2 (task 2):*** A speech task was administered in which participants were instructed, using a pre-recorded tape, to imagine themselves being accused of shoplifting. They were asked to prepare (during a two minute period) and then give a two minute defence while facing a web camera. A similar speech task has been used by others to successfully elicit stress responses among smokers and predict early smoking relapse (Al'absi, Hatsukami & Davis, 2005).

***Smoking cue (task 3):*** Participants were required to watch the lighting of a cigarette (one of their favorite brands) that was placed in front of them. They were asked to hold the cigarette between their fingers but were not allowed to smoke it. Shadel and colleagues (2001), and Carter and Tiffany (1999) also reported that in vivo cues resulted in greater craving reactivity than the use of video with smoking cues.

#### **4. 1.3. Dependent measures**

Cigarette craving was calculated by the two single items, “I have a desire for a cigarette right now” and “strength of desire to smoke right now” using a 7-point scale (1 = strongly disagree, 4 = neither agree nor disagree, 7 = strongly disagree), which has acceptable validity and reliability (Tiffany & Drobes, 1991) and sensitivity to change following exercise (Daniel et al., 2004; Ussher et al., 2001). Cronbach’s alpha ranged from .88 to .93 ensuring high reliability.

The smoking withdrawal symptoms were calculated from the following items from the Mood and Physical Symptoms Scale (MPSS): depression, tension, irritability, restlessness, poor concentration, stress, anxiety and energy. A five-point scale (1=not at all, 3=somewhat, 5=extremely) in response to the question, ‘How do you feel right now?’ was used. All items have been shown to be sensitive to change in response to exercise (e.g., Taylor et al., 2005) (see appendix 12). Cronbach’s alpha was ranged from .80 to .92.

Cravings and withdrawal symptoms were assessed at nine measurement points; (1) prior to treatment, (2) at mid-point of treatment, (3) at end of treatment, (4) immediately before and (5) after the first task, (6) immediately before and (7) after the second task, and (8) immediately before and (9) after the third task. Blood pressure and heart rate were also taken before and after each task as a manipulation check to ensure participants were engaged in the tasks; increases were expected to reflect psychological and physiological arousal. The final assessment point was approximately 50 minutes post treatment. The time from leaving the exercise centre to smoking the next cigarette was calculated from a text message sent from the participant’s mobile phone. Participants were instructed to send a

text message to an independent researcher's mobile phone informing them about the time they smoked their first cigarette after leaving the laboratory.

### *Additional measures:*

Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and Heart Rate (HR) were assessed before and after each task with the participant in a semi-recumbent seated position, and a BP cuff placed over the brachial artery of the non dominant arm (Digital BP Monitor Model UA-767PC, A & D Instruments). On each occasion, three measures were taken and the mean was calculated from them. The difference between pre- and post-stressor and smoking cue was calculated as a measure of cardiovascular responsiveness to the task.

Mean arterial pressure (MAP) was calculated using the formula:  $MAP = [(SBP - DBP/3)] + DBP$ . Blood pressure was not taken during the tasks to avoid distraction, although continuous heart rate was recorded, using the heart rate monitor. This was later used to confirm that response to the task peaked towards the end and that heart rate remained at this level immediately after the task ended at the time when blood pressure measures were taken. Participants received a payment of 10 pounds for their participation in the study.

## 4. 2 Results

Baseline characteristics for both exercise and control groups are shown in Table 4.1.

ANCOVAS's (controlling for order) revealed that order of treatment had no influence on the effects of exercise on cravings or withdrawal symptoms at baseline,  $F(1, 57) = 1.90, p = .95$  (Cohen's  $d = .17$ ). Furthermore ANCOVA'S (controlling for order) revealed that cravings and withdrawal ratings to the first two stressors (Stroop and speed tasks), which were presented randomly counterbalanced, were not influenced by order  $F(3, 55) = .28 \quad p = .84$  (Cohen's  $d = .06$ ).

	Exercise condition (n=31)	Passive condition (n=29)
	$\bar{x}$ (SD)	$\bar{x}$ (SD)
Age (years)	27.1 (5.5)	30.1 (9.7)
No. (% female)	20 (64%)	14 (48%)
FTND score	3.9 (2.3)	3.0 (2.1)
No. cigarettes smoked	15.0 (7.8)	14.9 (5.9)
Hours of moderate or vigorous intensity physical activity	4.9 (2.5)	4.9 (2.6)
Heart rate	65.8 (9.9)	64.5 (10.7)
Systolic blood pressure	113.9 (13.3)	112.8 (13.1)
Diastolic blood pressure	68.7 (7.9)	68.0 (8.0)
Mean Arterial Pressure	83.8 (8.9)	82.9 (8.8)
Height (m)	1.73 ( .5)	1.72 ( .1)
Weight (kg)	68.6 (10.9)	68.6 (13.1)
BMI (kg/m * m)	22.8 (2.5)	23.2 (3.9)
Withdrawal symptoms	2.1 (1.1)	1.9 ( .1)
Cravings	4.5 ( .2)	4.8 ( .2)

**Table 4.1:** *Baseline characteristics of study participants in the exercise and passive control condition.*

*Notes: Values are means (SD) unless stated otherwise. FTND: Fagerstrom Test for Nicotine Dependence (Heatherton et al., 1991).*

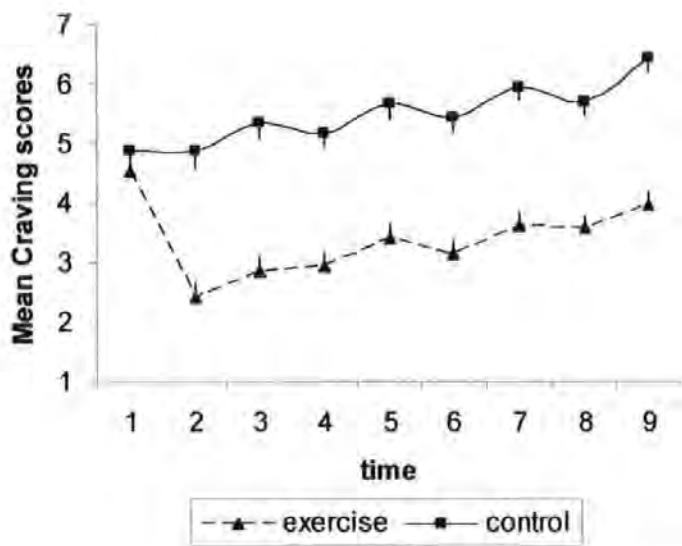
#### **4. 2.1. Effects of exercise on cravings and withdrawal symptoms and cue-elicited cravings**

In order to test hypothesis three concerning effects of exercise on absolute reduction in overall cravings and withdrawal symptoms, a 2 (exercise: walking, passive) x 9 (cravings: Times 1 to 9) x 9 (withdrawal symptoms: Times 1 to 9) mixed multi MANOVA was conducted with exercise as a between participants factor. Results supported statistically significant 2-way interaction effects between time and exercise on cravings  $F(5.5, 316.9) = 7.0, p < .01$  (Cohen's  $d = .6$ ) and withdrawal symptoms  $F(5.6, 326.7) = 8.3, p < .01$ , (Cohen  $d = .7$ ), all with a Greenhouse-Geisser correction. Planned contrasts revealed that at each time point, compared to baseline and passive group, the exercise group had significantly lower scores for cravings and withdrawal symptoms ( $p < .01$ ), as shown in Figures 4.1 and 4.2 (shown overleaf).

Moreover, in order to check whether the smoking status of the participants and their previous physical activity could control the effects of exercise on levels of cravings and withdrawal symptoms a 2 (exercise: walking, passive) x 9 (cravings: Times 1, Time 2, Time 3, Time 4, Time 5, Time 6, Time 7, Time 8, Time 9) x 9 (withdrawal symptoms: Times 1, Time 2, Time 3, Time 4, Time 5, Time 6, Time 7, Time 8, Time 9) ANCOVA was conducted with number of cigarette smoked daily and levels of physical activity as covariates. Results of the ANCOVAS when controlling for number of cigarettes smoked daily revealed non-significant interaction effects for levels of cravings  $F(8, 50) = 1.09, p = .38$  and partial  $\eta^2$  values decreased considerably from .11 to .01; and levels of withdrawal  $F(8, 50) = 4.22, p = 4.22$  and partial  $\eta^2$  values decreased considerably from .40 to .11. This finding suggests that the smoking status of the participants could control the effects of exercise on cravings and withdrawal.

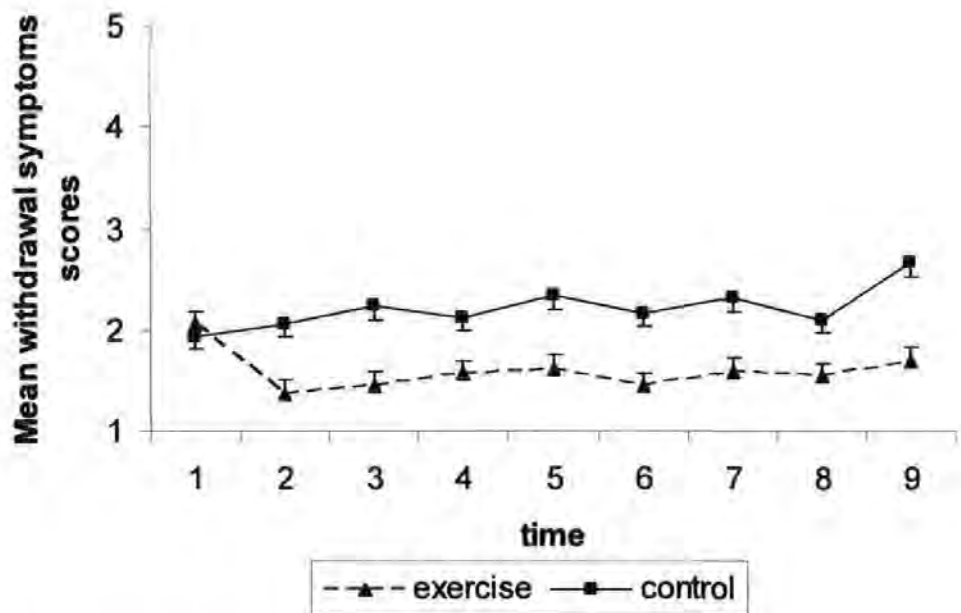


When controlling for participant’s levels of physical activity results of the ANCOVAs indicated that there were significant interaction effects which mean that the physical activity levels of the participants do not control the effects of exercise on levels of cravings and levels of withdrawal symptoms.



**Figure 4. 1:** *Changes in cravings to smoke in the exercise and control conditions, and pre and post three tasks.*

*Notes: Time: 1 (pre-treatment); 2 (mid- treatment); 3 (end- treatment); 4 & 5 (pre- and post-cue 1); 6 & 7 (pre- & post-cue 2); 8 & 9 (pre- & post lit cigarette).*



**Figure 4. 2:** *Changes in withdrawal symptoms, in the exercise and control conditions, and pre and post three tasks.*

*Notes:* Time: 1 (pre-treatment); 2 (mid- treatment); 3 (end- treatment); 4 & 5 (pre- and post-cue 1); 6 & 7 (pre- & post-cue 2); 8 & 9 (pre- & post lit cigarette).

The effects of exercise on withdrawal symptoms and cravings under different conditions of stress was examined through a series 2 (exercise: walking, passive) x 2 (Stroop stressor: Times 4, Time 5) x 2 (speech stressor: Times 6, Time 7) x 2 (lit cigarette: Times 8, Time 9) MANOVA using the different stressors as within participant factor and cravings and withdrawal symptoms as dependent variables. Results from these analyses revealed a statistically significant 2-way interaction between exercise and lit cigarette on withdrawal symptoms,  $F(1, 58) = 10.24, p < .01$  (Cohen's  $d = .8$ ) but not on cravings  $p > .05$ . The interactions between exercise and Stroop test and between exercise and speech were not statistically significant for cravings or withdrawal symptoms (all  $F$ s  $< 1.0, p$ s  $> .10$ ).

Table 3 displays participants' mean scores for cravings and withdrawal symptoms across the 6 time points. In this table, time points 4 to 9 are critical because these are the time points where (i) cravings and withdrawal symptoms have been measured after exercise and (ii) stressors have been administered. As a result, these are the time points that will show whether stressors attenuated (diminished) the positive effects of exercise on cravings and withdrawal symptoms. As shown in this table 4.2, while levels of withdrawal symptoms and craving were lower after exercise than before exercise (in comparison to the passive group), the administration of stressors at times 4, 6 and 8 did not increase cravings and withdrawal symptoms. It follows that the statistically-significant interaction between exercise and lit cigarette for withdrawal symptoms was due to the fact that the stressor increased levels of withdrawal symptoms for participants who did not exercise. These results therefore, are consistent with hypothesis three that predicted that the effects of exercise on withdrawal symptoms will be resistant to stressors but only when the stressor involved a lit cigarette.

		Baseline (T1) $\bar{x}$ (SD)	Mid-session (T2) $\bar{x}$ (SD)	Post-session (T 3) $\bar{x}$ (SD)	Pre-Stroop (T4) $\bar{x}$ (SD)	Post-Stroop (T 5) $\bar{x}$ (SD)	Pre-speech (T 6) $\bar{x}$ (SD)	Post-speech (T7) $\bar{x}$ (SD)	Pre-lit cigarette (T8) $\bar{x}$ (SD)	Post lit-cigarette (T 9) $\bar{x}$ (SD)
Cravings	<i>Exercise</i>	4.5( .2)	2.4( .3)	2.8(.3)	2.9(1.6)	2.9(1.6)	3.1(1.5)	3.6(1.5)	3.1(1.5)	3.9(1.7)
	<i>Control</i>	4.8( .2)	4.8( .3)	5.4(.3)	5.2(1.1)	5.6(1.1)	5.4(1.2)	3.9(1.7)	5.7( .8)	6.4( .7)
Withdrawal	<i>Exercise</i>	2.1(1.1)	1.3(1.1)	1.4(1.4)	1.5( .6)	1.6( .5)	1.4( .4)	1.5( .5)	1.5( .5)	1.7( .6)
	<i>Control</i>	1.9( .1)	2.1( .1)	2.2( .1)	2.1( .8)	2.3( .9)	2.1( .8)	2.3( .9)	2.1( .7)	2.6( .9)

**Table 4. 2:** Mean values,  $\bar{x}$  (SD), in the exercise and control conditions, and pre and post three tasks. The Stroop (1), a speech task (2), and holding a lit cigarette (3).

*Note:* Time; T1 (pre-treatment); T2 (mid- treatment); T3 (end- treatment); T4 &T 5 (pre- and post-cue 1); T6 & T7 (pre- & post-cue 2); T8 &T 9 (pre- & post lit cigarette).

#### **4. 2.2. Effects of exercise on ad libitum smoking behaviour**

To test hypothesis 4, concerning the time people smoked their next cigarette after leaving the laboratory, we calculated the mean time after leaving the facility before smoking the first cigarette and compared the differences between the two groups. Correlations and t-tests were conducted in order to test whether overall craving scores at the final assessment was associated with the time to ad libitum smoking.

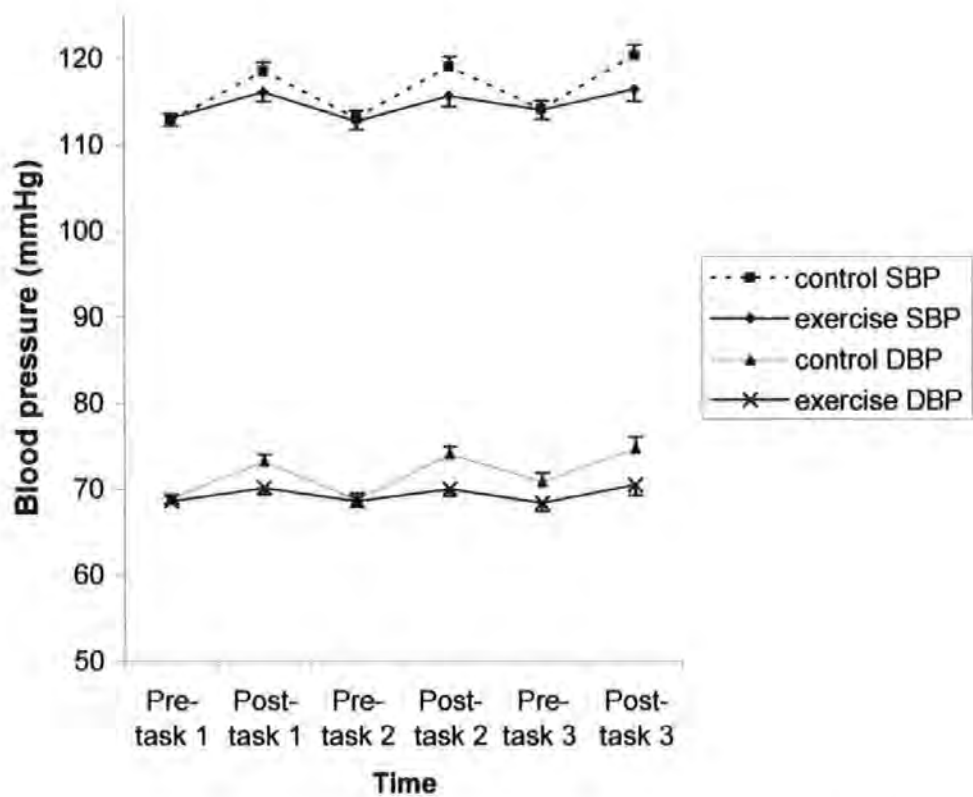
In support of hypothesis 4, the mean time after leaving the facility before smoking the first cigarette was 83.7 minutes (SD = 61.1) for the exercise group compared with 26.6 minutes (SD = 34.4) for the passive condition. The treatment effect was 57.2 minutes ( $t = 4.4$ ,  $p < .01$ ; 95%, CI 31.6 - 82.1), Cohen's  $d = 1.1$ . In addition craving scores, but not withdrawal symptoms, at the final assessment were associated with the time to ad libitum smoking,  $r = -0.28$ ,  $p < .05$ : The stronger the cravings to smoke the shorter the time to the next cigarette.

#### ***Additional analysis***

In order to examine the physiological reactivity to the stressors and the smoking cue we measure blood pressure and heart rate responses. T-tests revealed no significant differences between the groups at baseline on any variables. With data from both groups combined, there were significant increases in systolic and diastolic blood pressure, and heart rate in response to each task (overall mean response SBP/ DBP = 4.3/2.9 mmHg, and heart rate of 2.3 beats per minute), thereby supporting the role of each as a mental challenge. A two-way mixed ANCOVA 2 (exercise: walking, passive) x 2 (Stroop stressor: Times 4, Time 5) x 2

(speech stressor: Times 6, Time 7) x 2 (lit cigarette: Times 8, Time 9), using the different stressors as within participant factor and Blood Pressure (BP), or Heart Rate (HR) or Mean arterial pressure (MAP) as dependent variables, (controlling for baseline BP, HR and MAP) revealed a significant overall interaction effect for time by exercise for SBP, DBP and MAP:  $F(3.5, 186.3) = 3.5, p = .01$ ;  $F(3.5, 192.2) = 2.8, p < .05$ ;  $F(3.4, 183) = 4.4, p < .01$ , respectively (with a Greenhouse–Glasser correction). Effect sizes Cohen  $d$  for SBP, DBP and MAP are .5, .4, .6, respectively.

SBP and DBP data are shown in Figure 4.3. Univariate ANCOVAs (to compare between-groups post-stressor BP, controlling for pre-stressor BP) revealed that the exercise group had significantly ( $p < .05$ ) lower responses to tasks 1, 2 and 3, respectively: SBP,  $F(1, 54) = 3.9, 5.5, 7.1$ ; DBP,  $F(1, 54) = 4.8, 5.1, 1.5$ , ns. MAP,  $F(1, 54) = 6.6, 9.7, 3.3$ , ns. Effect sizes for the adjusted post-task differences ranged from  $-0.54$  to  $-0.68$  for SBP and  $-0.33$  to  $-0.68$  for DBP, equivalent to an attenuated SBP and DBP of up to 3.8 mmHg. Similar analyses revealed no significant differences in HR response to the tasks between groups.



**Figure 4. 3:** *Mean (SE) SBP and DBP responses to 3 tasks following exercise or passive condition, adjusted for baseline values. Task 1: Stroop, task 2: a speech task and task 3: holding a lit cigarette.*

Correlations were also conducted in order to examine the relationship between cravings and withdrawal symptoms both cross-sectionally and in terms of change in response to the treatment. Cross-sectional correlations between cravings, and withdrawal symptoms were determined, at each time point that they were measured (T1 - T9). Also change scores (between pre- and 50-minutes post exercise, T1-T9) were calculated and correlations between these scores were determined. The results of the analysis revealed that at each time point levels of cravings were highly associated with levels of withdrawal symptoms (see table 4.3). Reductions in levels of cravings were also associated with reductions in levels of withdrawal symptoms between baseline and the end of the session.

Correlation between cravings and withdrawal (T1)	Correlation between cravings and withdrawal (T2)	Correlation between cravings and withdrawal (T3)	Correlation between cravings and withdrawal (T4)	Correlation between cravings and withdrawal (T5)	Correlation between cravings and withdrawal (T6)	Correlation between cravings and withdrawal (T7)	Correlation between cravings and withdrawal (T8)	Correlation between cravings and withdrawal (T9)	Correlation between change in cravings and change in withdrawal  T1-T9
.13	.41**	.38**	.47**	.60**	.43**	.37**	.51**	.54**	.65**

**Table 4. 3:** Cross-sectional (from T1-T9) and change (from T1-T9) correlation between cravings, and withdrawal symptoms. \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$ .

Notes Time: T1 (pre-treatment); T2 (mid- treatment); T3 (end- treatment); T4 & 5 (pre- and post-cue 1); T6 & 7 (pre- & post-cue 2); T8 & 9 (pre- & post lit cigarette).

### 4. 3 Discussion

This study compares favourably with previous research (Daniel et al., 2004; Taylor et al., 2005; Taylor et al., 2006; Ussher et al., 2001) that has showed a beneficial effect of exercise on cravings for a cigarette and withdrawal symptoms. Notably, for the first time, it was shown that 15 minutes of low-moderate intensity exercise not only reduced absolute cravings but also attenuates increases in withdrawal symptom responses to a smoking cue. Furthermore, the results of the study extended findings from Study 1 that showed that exercise can reduce absolute cravings and withdrawal symptoms for up to 20 minutes (see Study 1) by showing that the effects of exercise could last for at least 50 minutes following exercise.

Hypothesis 3 predicted that a self-paced 15 minute walk would reduce levels of cravings and withdrawal symptoms in comparison to the control condition. Further, exercise will attenuate increases in cue-elicited cravings and withdrawal symptoms in comparison to the passive control group. In partial support of hypothesis 3 results showed that during and following exercise, levels of withdrawal symptoms and cravings were significantly lower in comparison with the equivalent scores in the control condition. It was also shown that withdrawal symptoms but not cravings did not increase, in comparison with the control, in response to the lit cigarette. Participants in the control group were experiencing high levels of cravings prior to the presentation of the lit cigarette and therefore a ceiling effect on cravings levels might have masked the extent of cue elicited cravings. Nevertheless, the present findings may be important given that Shiffman and colleagues, (1996) reported that urge intensity during temptations predicted a lapse on the first day of a quit attempt.

It was somewhat surprising to see that exercise did not attenuate craving and withdrawal symptom responsivity to the Stroop or speech task. The results of the additional analysis of the blood pressure and heart rate shows the two tasks increased physiological arousal and that the increases were significantly smaller in the exercise group. If stress does drive the desire to smoke (Parrott, 1998), then it is unclear why increases in blood pressure were not associated with increases on the self-reported measures of cravings and withdrawal symptoms. An explanation for these findings might be that although smokers felt an elevated physiological stress during the presentation of the stressors they did not associate it with lack of smoking. On the other hand when smokers were presented with the smoking related cue (the presentation of the lit cigarette) this prompted them to associate the stress they were experiencing with the lack of smoking. This is further supported by studies that



have shown that smoking related cues are more efficient in eliciting smoking related cravings and withdrawal symptoms than neutral cues (Carter & Tiffany, 1999; Shadel et al., 2001). Future studies should consider the effects of exercise on these and other (possibly more potent) stressors. The results of the correlations between levels of cravings and withdrawal symptoms revealed that levels of cravings and levels of withdrawal symptoms are positively associated. This finding compares favourably with previous research that has repeatedly reported that people smoke in order to deal with negative affect (Kelly, Barrett, Pihl & Dagher, 2004).

Hypothesis 4 predicted that the time before participants have their next ad libitum cigarette after leaving the laboratory will be extended following exercise. Furthermore, cravings measures would be negatively associated with time to smoking the next cigarette. In support of hypothesis 4 the results of the study showed that the lag time to the next cigarette, after leaving the laboratory, was 57 minutes longer for the participants who walked in comparison to the participants who undertook the passive control condition. This is the first study to use text messaging by cellular phone to assess the effects of exercise on ad libitum smoking. If time is calculated from end of treatment (i.e., equivalent to termination of exercise) to the next cigarette this was a mean of 134 minutes (50 + 84 minutes) for the exercise group and 77 minutes for the control group. The small but significant correlation between measures of cravings at the final laboratory assessment and time to ad libitum smoking supports the predictive utility of these craving measures. Extending the period between cigarettes may have the potential to reduce the number of cigarettes smoked in a day, thereby resulting in harm reduction (deRuiter & Faulkner, 2006).

In summary, the findings of the present study indicate that a 15 minute walk can reduce cravings and withdrawal symptoms and the effects can last for at least 50 minutes following exercise. Furthermore, although the effects of exercise are resistant to two stressors and a smoking cue, exercise only attenuates increases in cue eliciting withdrawal symptoms after the presentation of the lit cigarette. Extending the observed affects of exercise in the laboratory to ad libitum smoking behaviour increases the external validity of the findings. Relatively short periods of brisk walking should be prescribed as an aid to managing cravings and withdrawal symptoms, both in general and when faced with environmental smoking stimuli.

ANCOVAs when controlling for the previous smoking status of the participants indicated that participants smoking status could control the effects of exercise on cravings and the associated withdrawal symptoms. This finding is in line with findings of study 1 that also suggested that participants smoking status could control the effects of exercise on cravings, urges to smoke, mood and affect. Participants in the present study were also moderate smokers smoking on average 15 cigarettes daily, future studies should examine the effects of exercise in cue elicited cravings and withdrawal symptoms in light and heavy smokers.

## **Chapter 5**

### **5. Study 3**

#### **5. 0 Introduction**

The results of Study 2 extended previous research (Daniel et al., 2004; Taylor et al., 2005; Taylor et al., 2006; Ussher et al., 2001) by showing a beneficial effect of exercise on cravings for a cigarette and withdrawal symptoms even under conditions of stress. Notably, for the first time, it was shown that 15 minutes of low-to-moderate intensity exercise not only reduces absolute cravings, but also attenuates increases in withdrawal symptom responses to a smoking cue.

It was somewhat surprising to observe that exercise only attenuated increases in withdrawal symptoms only after the presentation of the lit cigarette and did not attenuate responsiveness to the Stroop (with the exception of restlessness) or speech task. This suggests that the lit cigarette cue was more potent in the study of exercise and cue reactivity in smokers. Accordingly, previous research has shown that visual, auditory, and tactile (paraphernalia) smoking cues resulted in increased urge and craving to smoke, to a greater extent than non-smoking-related cues (Lazev, Herzog & Brandon, 1999; Sayette, Martin, Wertz, Shiffman & Perrott, 2001; Tiffany, Cox & Elash, 2000). Nevertheless, the observed effects of the particular cue may be a result of the accumulation of effects from the other two stressors (the lit cigarette was always presented towards the end of the experiment). Therefore further research is needed in order to examine further the potency of the lit

## Chapter 5: Study 3

cigarette cue to elicit cravings and withdrawal symptoms. Determining and identifying the efficacy of different smoking cues associated with smoking craving and relapse is important in order to further examine the relapse-preventing efficacy of exercise.

### 5. 0.1. Aims and Hypotheses

Study 2 is the first study to examine the effects of exercise in cue reactivity among smokers. Given the recent interest in cue-elicited craving research, further studies should examine the potency of the lit cigarette cue to elicit cravings and withdrawal symptoms. This is important as it can further specify the relapse-preventing efficacy of exercise.

Using a within-participants counterbalanced design, the aim of Study 3 was to examine the effects of a fifteen minute walk versus passive waiting on withdrawal symptoms and cravings, in response to a single smoking cue (with no prior stressor) in smoking abstinent smokers (2 hour abstinence). Further, the study aimed to examine the time it took the participants had their next ad libitum cigarette after leaving the laboratory.

Study 3 examined the following hypotheses:

***Hypothesis 5:*** Exercise will attenuate increases in cravings and withdrawal symptoms, elicited by the presence of a lit cigarette, in comparison to a passive control group.

***Hypothesis 6:*** The time participants have their next ad libitum cigarette, after leaving the laboratory, will be extended following exercise. Furthermore, cravings measures would be negatively associated with time to smoking the next cigarette.

## **5. 1 Materials and methods**

### **5. 1.1. Participants and procedures**

Following ethical approval from the University Research Ethics Committee, smokers were recruited through public advertisements and were screened by telephone. Participants had to be 18 to 50 years of age, smoked at least ten cigarettes daily for the past three years, not pregnant, and not receiving any psychiatric treatment or suffering any medical condition that was contraindicated for physical activity (Thomas et al., 1992) (see appendix 1). One participant was excluded due to a medical reason, and three decided not to participate in the study. Participants provided informed consent and were asked to abstain from smoking, caffeine intake and exercise for two hours prior to their visit to the laboratory. The limit to two hours of abstinence was necessary to avoid high baseline cravings that may lead to a ceiling effect when conducting a cue-eliciting craving study (Carter & Tiffany, 1999; Schuh & Stitzer, 1995). They were also asked to bring a packet of their favourite cigarette brand and a mobile phone to the session.

Upon arrival at the laboratory, participants were given verbal and written information about the study and then they provided informed consent (see appendix 11). Expired carbon monoxide (CO) levels were used to confirm abstinence ( $< 15$  ppm) upon arrival at the testing (Bedfont Smokerlyzer). Measures of weight, height, resting heart rate and systolic and diastolic blood pressure (SBP/DBP) (Digital BP Monitor Model UA-767PC, A & D Instruments) were taken, and body mass index (BMI) was calculated, to provide descriptive data for the sample. Self-reported nicotine dependence was assessed using the Fagerström Test for Nicotine Dependence: FTND (Heatherton et al., 1991) (see appendix 4). Physical

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activity was assessed using the self-report 7-day recall measure, which has been shown to have acceptable validity and reliability (Blair et al., 1985) (see appendix 5).

In a within participants design, thirty participants were randomly assigned to either an exercise ( $n = 31$ ) or passive ( $n = 29$ ) group in a counterbalanced design to control for order effects. Participants were then fitted with a heart rate monitor (Advantage, POLAR) and taken to either a quiet room or one with an exercise treadmill, depending on the condition they were assigned to.

### 5. 1.2. Treatment

*Exercise session:* This consisted of a two minute warm-up at 4km/hr, followed by a 15-minute flat walk on a treadmill at a semi-preferred intensity, and 2 minute cool down at 4km/hr. We describe it as semi-preferred since participants were instructed to walk briskly for 15 minutes (as if they were late for an important appointment but not to the point of breathlessness) but had some control over the intensity. The research assistant modified the treadmill speed as requested but engaged in minimal verbal dialogue. To determine exercise intensity a Rating of Perceived Exertion (RPE) using the 6-20 Borg scale (Borg, 1998) (see appendix 3) was recorded every two minutes together with continuous heart rate. The mean (standard deviation) exercise intensity for walkers was subsequently calculated:  $HRR=37.3$ ; mean Rating of Perceived Exertion (RPE) = 12.2 (i.e., 'fairly light').

*Passive session:* This took place in a quiet room, same as the one where the exercise took place but instead of a treadmill there was a desk. Participants were asked to sit quietly and were spoken to only when craving and withdrawal symptom measures were administered. Participants were not asked about RPE. The decision to use a passive control condition followed careful consideration of previous studies. First, Ussher et al. (2001) and Daniel et

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al (2006) both concluded that exercise reduced cravings and withdrawal symptoms even when compared with a distracting task. Second, the duration of reduced cravings (50 minutes) after exercise, and the fact that the effects of exercise were extended for up to 57 minutes after people left the laboratory,( as shown in Study 2), would suggest that distraction is not the main mechanism (Taylor et al., 2007). Third, the same passive conditions have been shown to produce stable reporting of cravings and withdrawal symptoms (Taylor et al., 2005). Ten minutes after the treatment session participants were taken to an adjacent room. Participants then underwent further assessments prior to and after an in vivo smoking cue, the presentation of a lit cigarette.

*Smoking cue:* Participants were required to watch the lighting of a cigarette (one of their favorite brands) that was placed in front of them. They were asked to hold it between their fingers but were not allowed to smoke it. Shadel and colleagues (2001), and Carter and Tiffany (1999) also reported that in vivo cues resulted in greater craving reactivity than the use of video with smoking cues.

### 5. 1.3 Dependent measures

Cigarette craving were calculated by averaging the single items, 'I have a desire for a cigarette right now' and the 'Strength of desire to smoke' item that were both using a seven-point scale (1=strongly disagree, 4=neither agree nor disagree, 7=strongly agree) was assessed using a seven-point scale. Both single-item measures have been shown to be sensitivity to change in response to exercise (e.g., Ussher et al., 2001) and have acceptable validity and reliability (West and Russell, 1985). Cronbach's alpha ranged between .80 and .90.

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The smoking withdrawal symptoms were calculated by averaging the single items of depression, tension, irritability, restlessness, poor concentration, stress and anxiety from the Mood and Physical Symptoms Scale (MPSS) (West & Hajek, 2004) (see appendix 12). A five-point scale (1=not at all, 3=somewhat, 5=extremely) in response to the question, 'How do you feel right now?' was used. Cronbach's alpha ranged between .50 and .90.

Measures of cravings and withdrawal symptoms were assessed at five measurement points: (1) prior to treatment, (2) at mid-point of treatment, (3) at end of treatment, (4) immediately before and (5) after the presentation of the lit cigarette. Blood pressure and heart rate were also taken before and after the presentation of the cue as a manipulation check to ensure participants were engaged in the tasks; increases were expected to reflect psychological and physiological arousal. The final assessment point was approximately 30 minutes post treatment. The time from leaving the exercise centre to smoking the next cigarette was calculated from a text message sent from the participant's mobile phone. Participants were instructed to send a text message when they smoked their first cigarette after leaving the laboratory.

### *Additional measures:*

Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and Heart Rate (HR) were assessed before and after the presentation of the lit cigarette, with the participant in a semi-recumbent seated position, and a BP cuff placed over the brachial artery of the non dominant arm (Digital BP Monitor Model UA-767PC, A & D Instruments). On each occasion, three measures were taken and the mean was calculated from them. The difference between pre- and post-stressor was calculated as a measure of cardiovascular responsiveness to the task. Mean arterial pressure (MAP) was calculated using the formula:



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MAP= [(SBP-DBP/3)] +DBP. Blood pressure was not taken during the task to avoid distraction, although continuous heart rate was recorded, using the heart rate monitor. Participants received a payment of 10 pounds for their participation in the study.

### 5. 2 Results

Baseline characteristics for both exercise and control groups are shown in Table 5.1

ANCOVA's (controlling for order revealed) that order of treatment had no influence on the effects of exercise  $F(1, 28) = .08, p = .77$  (Cohen's  $d = .33$ ). ANCOVA's (controlling for order) also revealed that responses to the lit cigarette was not influenced by order,  $F(1, 28) = .02, p = .97$  (Cohen's  $d = .17$ ). Paired t-test at baseline between cravings (control vs. exercise) and withdrawal symptoms (control vs. exercise) did not revealed significant statistical differences  $p > .10$ .

Nevertheless, paired t-test at baseline between cravings and withdrawal symptoms revealed significant statistical differences  $p < .01$  This finding suggests that the brief smoking abstinence prior to the study although it was sufficient to induce high levels of cravings was not sufficient to induce levels of withdrawal symptoms (see Table 5.1)

	Session involving the walk  (n=30)  $\bar{x}$ (SD)	Session involving the Passive condition  (n=30)  $\bar{x}$ (SD)
Age (years)	21.86 (2.09)	
sex	13 males, 17 females	
FTND score	8.0 (3.5)	
Order, no of people starting with the exercise and control conditions	14 (7 males, 7 females)	16 (6 males, 10 females)
Hours of moderate or vigorous intensity physical activity	4.8 (2.3)	4.5 (1.6)
No. cigarettes smoked	25 (13.7)	
Heart rate	69.78 (10.3)	70.65 (9.9)
Systolic blood pressure	119.7 (8.3)	119.25 (9.8)
Diastolic blood pressure	67.0 (6.2)	66.7 (6.7)
Mean Arterial Pressure	97.42 (7.5)	
Height (m)	1.7 ( .2)	
Weight (kg)	70.2 (8.0)	
BMI (kg/m * m)	22.2 (4.2)	
Withdrawal symptoms	2.2 ( .7)	2.1 ( .8)
Cravings	5.5 (1.2)	4.9 (1.2)

**Table 5. 1:** *Baseline characteristics of study participants in the exercise and passive control condition.*

*Note: Values are means (SD) unless stated otherwise. FTND: Fagerstrom Test for Nicotine Dependence (Heatherton et al., 1991).*

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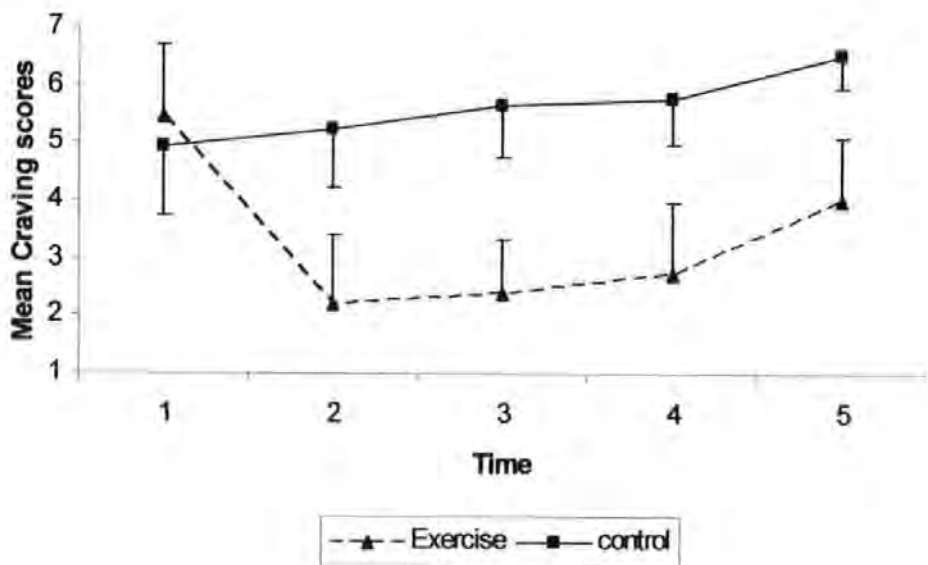
### *Preliminary analyses*

To examine the effects of exercise on cravings and withdrawal symptoms a series of 2 (exercise: walking, passive) x 5 (cravings: Time 1, Time 2, Time 3, Time 5, Time 5) x 5 (withdrawal symptoms: Time 1, Time 2, Time 3, Time 5, Time 5) MANOVA was conducted with exercise, cravings and withdrawal symptoms as within-participants factors. Results supported statistically significant 2-way interactions between cravings and exercise  $F(4.0, 116) = 49.2, p < .01$  (Cohen's  $d = 1.7$ ) and between exercise and withdrawal symptoms  $F(2.7, 77.6) = 33.9, p < .01$  (Cohen's  $d = 1.4$ ), with a Greenhouse-Geisser correction. Planned contrasts revealed that at each time point, compared to baseline, the exercise group had significantly lower scores, for cravings and withdrawal symptoms ( $p < .01$ ) than the control condition, as shown in Figures 5.1 and 5.2.

Moreover, in order to check whether the smoking status of the participants and their previous physical activity could control the effects of exercise on levels of cravings and withdrawal symptoms a 2 (exercise: walking, passive) x 5 (cravings: Time 1, Time 2, Time 3, Time 4, Time 5) x 5 (withdrawal symptoms: Time 1, Time 2, Time 3, Time 4, Time 5) ANCOVA was conducted with number of cigarette smoked daily and levels of physical activity as covariates. Results of the ANCOVAs when controlling for number of cigarettes smoked daily revealed non-significant interaction effects for levels of cravings  $F(4, 25) = 1.06, p = .39$  and partial  $\eta^2$  values decreased considerably from .31 to .14; and levels of withdrawal  $F(4, 25) = 2.19, p = .09$  and partial  $\eta^2$  values decreased considerably from .32 to .26. This finding suggests that the smoking status of the participants could control the effects of exercise on cravings and withdrawal.

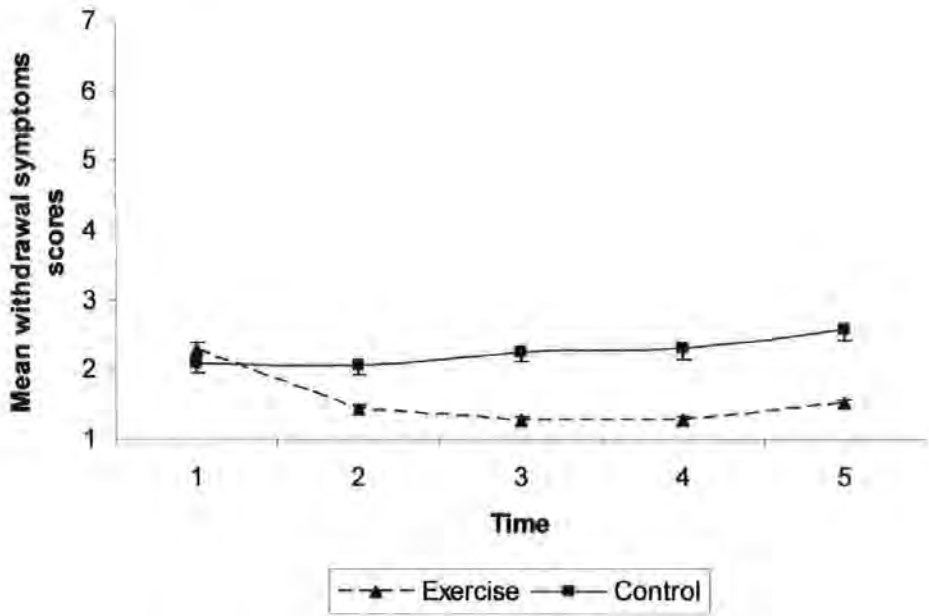
When controlling for participant's levels of physical activity results of the ANCOVAs significant interaction effects were still observed which means that the physical activity

levels of the participants do not control the effects of exercise on levels of cravings and levels of withdrawal symptoms.



**Figure 5. 1:** *Changes in cravings in the exercise and control conditions, and pre and post the smoking cue.*

*Notes: Time: 1 (pre-treatment); 2 (mid- treatment); 3 (end- treatment); 4 & 5 (pre- and post-lit cigarette).*



**Figure 5. 2:** *Changes in withdrawal symptoms in the exercise and control conditions, and pre and post smoking cue.*

*Notes:* Time: 1 (pre-treatment); 2 (mid- treatment); 3 (end- treatment); 4 & 5 (pre- and post-lit cigarette).

### **5. 2.1. Effects of exercise on cravings and withdrawal symptoms, elicited by the smoking cue**

In order to test hypothesis five concerning the effects of exercise on withdrawal symptoms and cravings after the presentation of the lit cigarette, a 2 (exercise: walking, passive) x 2(lit cigarette: time 4, time 5) MANOVA was conducted using exercise and lit cigarette as a within-participants factor and cravings or withdrawal as depended variables. Results from these analyses revealed statistically significant interactions between exercise and lit cigarette on cravings,  $F(1, 29) = 4.4, p < .05$ , (Cohen's  $d = .5$ ) but not on withdrawal symptoms.

Table 5.2 displays participant’s mean scores for cravings and withdrawal symptoms across the 5 time points. In this table, time points 4 and 5 are critical because these are the time points where (i) cravings and withdrawal symptoms have been measured after exercise and (ii) the lit cigarette have been administered. As a result, these are the time points that will show whether the stressor attenuated (diminished) the positive effects of exercise on cravings and withdrawal symptoms. As shown in this table, levels of withdrawal symptoms and craving were lower after exercise than before exercise (in comparison to the passive group). Planned contrasts, for exercise versus control at point 5 (post presentation of the lit cigarette) revealed that people who exercised had significantly lower scores for cravings and withdrawal symptoms. It worth noting that the high levels of cravings in the control condition at time T5, indicates that levels of craving have reached a ceiling effect which have disguise their true extent.

		Baseline (T1) $\bar{x}$ (SD)	Mid-session (T2) $\bar{x}$ (SD)	Post-session (T3) $\bar{x}$ (SD)	Pre-lit cigarette (T4) $\bar{x}$ (SD)	Post- lit- cigarette (T5) $\bar{x}$ (SD)
Cravings	<i>Exercise</i>	5.5 ( .2)	2.2 ( .2)	2.4 ( .2)	2.7 ( .2)	4.0 ( .2)
	<i>Control</i>	4.9 ( .2)	5.2 ( .2)	5.6 ( .2)	5.7 ( .2)	6.7 ( .1)
Withdrawal	<i>Exercise</i>	2.3 ( .1)	1.4 ( .1)	1.3 ( .1)	1.3 ( .1)	1.5 ( .1)
	<i>Control</i>	2.1 ( .2)	2.1 ( .2)	2.3 ( .1)	2.3 ( .2)	2.6 ( .2)

**Table 5. 2:** Mean values of exercise and control conditions on cravings and withdrawal symptom and responses to holding a lit cigarette.

Notes: Time: T 1 (pre-treatment); T2 (mid- treatment); T3 (end- treatment); T4 & T5 (pre- and post-lit cigarette).

### 5. 2.2. Effects of exercise on ad libitum smoking behaviour

To test hypothesis six, we calculated the mean time after leaving the facility before smoking the first cigarette and compared the differences between the two groups.

Correlations were also conducted in order to test whether craving scores and withdrawal symptoms at the final assessment was associated with the time to ad libitum smoking.

The mean time after leaving the facility before smoking the first cigarette was, 66 minutes (SD=48) following exercise compared with 31 minutes (SD = 33) after the control condition,  $F(1, 19) = 8.5, p < .01$  ((Cohen's  $d = .7$ ). Cravings, but not withdrawal symptoms, at the final assessment was associated with the time to ad libitum smoking, there was a significant correlation,  $r = -.29, p < .05$ : The stronger the cravings to smoke the shorter the time to the next cigarette. Overall, in support of hypothesis six, exercise extended the time that people smoked their first cigarette after leaving the laboratory. Furthermore, cravings at the final assessment were correlated with ad libitum smoking.

#### *Additional analysis*

Although it was beyond the scope of the present investigation we also examined the effects of exercise on blood pressure (BP) and heart rate (HR) pre and post the presentation of the lit cigarette. This analysis was conducted in order to investigate the effect of the smoking cue on physiological reactivity. Using series 2 (exercise: walking, passive) x 2 (lit cigarette: pre, post) analysis with BP or HR as a within participants factors controlling for baseline BP or HR, there were not any significant interaction effects  $p > .10$ . This mean that the stressor although it induces self reported levels of cravings, the level of cravings were not associated with increases in physiological arousal. We also conducted correlations in order

to examine the relationship between cravings and withdrawal symptoms both cross-sectionally and in terms of change in response to the treatment. Cross-sectional correlations between cravings, and withdrawal symptoms were determined, at each time point that they were measured (T1 to T5). Also change scores (between baseline and post the presentation of the lit cigarette, T1 to T5) were calculated and correlations between these scores were determined. The results of the analysis revealed that levels of cravings were not associated with levels of withdrawal symptoms at any time point.

### **5. 3 Discussion**

This study compares favourably with previous research, which shows that walking has a beneficial effect in reducing cravings and withdrawal symptoms and that the effects were resistant to the smoking cue. Furthermore, when participants had the freedom to smoke in the natural environment, exercise led to a net greater time of 35 minutes before smoking.

Hypothesis five predicted that exercise will attenuate increases in cravings and withdrawal symptoms, elicited by the presence of a lit cigarette, in comparison to a passive control group. Rejecting hypothesis 5, results of the present study suggested that exercise did not attenuate increases in cravings or withdrawal symptoms in response to the smoking cue.

Nevertheless, planned contrasts revealed that for those participants who undertook exercise, levels of cravings and withdrawal symptoms were significantly lower after the presentation of the lit cigarette, in comparison to the control condition. An explanation of these effects is that the brief smoking abstinence induced high levels of cravings before the presentation of the lit cigarette. Therefore, a ceiling effect at the control condition disguised the purpose of examining the extent of cue elicited cravings.



## Chapter 5: Study 3

On the other hand, although the brief smoking abstinence induced high levels of cravings, it was not sufficient to induce withdrawal discomfort. Participants in the control session were experiencing only mild withdrawal discomfort and therefore the lit cigarette cue did not significantly induce their symptoms.

Results of the additional analysis on blood pressure and heart rate pre and post the presentation of the smoking cue, suggested that the presentation of the lit cigarette did not induce physiological arousal in the control group. It was contradictory to find that although the smoking cue induced self-reported levels of cravings, it did not induce physiological arousal. If increased stress is associated with increased cravings to smoke, it seems that the smoking cue increases tobacco appetite not because of induced physiological arousal/stress but probably due to induced negative affect associated for not being able to smoke (Niaura et al. 1988, 1992, 1998; Carter and Tiffany 1999; Hutchison et al. 1999; Tiffany et al. 2000; Sayette et al., 2001). In contrast with findings of studies one and two, it was also surprising to find out that levels of cravings were not associated with levels of withdrawal symptoms. This may be explained if one look at table 5.2 which illustrates the mean values of cravings and withdrawal symptoms throughout the study. From the table it is obvious that although mean values for cravings were high (especially for the control), the associated values for withdrawal symptoms were very low. That could possibly mean that although the brief smoking abstinence was sufficient to induce cravings, it was not sufficient to induce levels of withdrawal symptoms. The deleterious effects of abstinence in mood and withdrawal symptoms develop more slowly than cravings, over a time course that may be quite variable. Environmental demands, situational cues, past smoking habits and general expectations may influence abstinence effects, probably to varying degrees with different types of smokers (Parrot, 1998).

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Hypothesis six predicted that the time before participants have their next ad libitum cigarette will be extended following exercise. Furthermore, cravings measures would be negatively associated with time to smoking the next cigarette. In support of hypothesis six, a self-paced walk extended the time that people smoked their first cigarette after leaving the laboratory. Participants who walked smoked their next cigarette 35 minutes later in comparison to the participants who undertook the passive control condition. This study compares favourably with findings of study 2 that also shown that exercise increased the lag time to the next cigarette by 57 minutes.

The difference in the lag time to the next cigarette between Studies 2 and 3, is still not easy to explain. Although in Study 2 participants were exposed to more stress than those in Study 3, and although they remained smoking abstinent for longer time, their lag time to the next cigarette was longer than in Study 3. This difference in the lag time to the next cigarette may be due to the fact that participants in Study 3 responded to a greater intensity exercise ( $HRR = 37.3\%$ ;  $RPE = 12.2$ ) than those in Study 2 ( $HRR = 24.1\%$ ;  $RPE = 10.9$ ), and therefore this may have effected their post exercise experience. It was also shown from the Fagerström Test for Nicotine Dependence, FTND scores (Heatherton et al., 1991), as well from the number of cigarettes smoked daily, that participants in Study 3 were heavier smokers,  $FTND = 8$  (3.5) and smoked on average 25 (13.7) cigarettes daily, in comparison to those participants in Study 2,  $FTND$  scores = 3.9 (2.3) and smoked on average 15.0 (7.8) cigarettes daily. This is further supported from the results of the ANCOVAs in studies 2 and 3 that have indicated that the smoking status of the participants could control the effects of exercise on levels of cravings and withdrawal symptoms. Therefore, from these findings one can conclude that the effects of exercise on the lag time on the next cigarette is also depended on participants smoking status.

## Chapter 5: Study 3

In agreement with Study 2, the small but significant correlation between measures of cravings and time to ad libitum smoking at the final laboratory assessment support the predictive utility of these craving measures. Extending the period between cigarettes may have the potential to reduce the number of cigarettes smoked in a day, thereby resulting in harm reduction (deRuiter & Faulkner, 2006). Exercise would therefore be effective not only for people who are trying to quit but may also be an effective aid for those who just want to cut down on their smoking.

In summary, the findings of the present study reveal the potency of the smoking cue (the presentation of the lit cigarette), to induce levels of cravings in abstinent smokers and supports the relapse preventing efficacy of exercise. Overall, findings of this study support findings of Study 2, and indicate that a 15-minute walk can reduce overall cravings and withdrawal symptoms and the effects are resistant to the lit cigarette. Also, extending the observed affects of exercise in the laboratory to ad libitum smoking behaviour increases the external validity of the findings. Relatively short periods of brisk walking should be prescribed as an aid to managing cravings and withdrawal symptoms, both in general and when faced with environmental smoking stimuli.

## **Chapter 6**

### **6.0 Study 4**

#### **6. 0 Introduction**

The results of Studies 2 and 3 revealed that a 15-minute walk reduced cravings and withdrawal symptoms in comparison to a passive control condition and that the effects were evident even after the presentation of stressors and smoking cues. Furthermore, in both studies the lag time to the next cigarette was longer in the exercise group in comparison to the passive control.

Results of Studies 2 and 3 suggested that exercise can reduce overall cravings and withdrawal symptoms and that the effects are resistant to the lit cigarette. Furthermore, results of both studies suggested that exercise did not attenuate increases in levels of cravings. In addition, while study 2 revealed that exercise attenuated increases in levels of withdrawal symptoms in response to the smoking cue, results of study 3 did not support this finding.

The inconsistency of the findings on the effects of exercise on cue elicited withdrawal symptoms could be explained if one considers that the brief smoking abstinence in Study 3 was not sufficient to induce levels of withdrawal discomfort. Therefore, participants in study 3 did not suffer withdrawal discomfort, which has limited the purpose of examining cue elicited withdrawal symptoms. Moreover, participants in study 2, before the presentation of the lit cigarette, were smoking abstinent for a longer period than participants

## Chapter 6: Study 4

in Study 3. They had also been exposed to two additional stressful situations (Stroop and speech task). Therefore, in comparison to Study 3, the longer smoking abstinence and the accumulative effects of the stressors, induced high levels of withdrawal discomfort, prior to the presentation of the lit cigarette.

An explanation of the findings on the effects of exercise on cue elicited cravings, in studies 2 and 3, is that the smoking abstinence resulted in high cravings, (especially prior to the presentation of the smoking cue), and a ceiling effect in the control condition limited the scope for observing cue-elicited cravings.

In order to further examine the potency of the smoking cue to elicit cravings and the relapse-preventing efficacy of exercise, further research is warranted to replicate Study 3 and examine the effects of exercise among non-abstinent smokers.

Research suggests that even non-abstinent smokers could show reactivity on craving levels when they are exposed to smoking cues. This is because the autonomic responses of cigarette cravings may be depended on the perceived reinforcing value of cigarettes, which can be modulated by smoking abstinence (Kelly, Barrett, Pihl & Dagher, 2004). In order to establish exercise as an aid to cope with cravings it is important to explore the effects of exercise in cue elicited cravings in smokers during different periods of smoking abstinence and non-abstinence. Recognising the condition of the smoker is a critical determinant in cravings response and can identify the relapse-preventing efficacy of exercise.

Non-abstinent smokers will not experience cravings and withdrawal symptoms at the onset of the study. Therefore the control passive condition will not reach a ceiling effect towards the end of the study, before the presentation of the lit cigarette. This will reveal the potency

of the smoking cue to trigger cravings and the efficacy of exercise to attenuate cue elicited cravings in comparison to the control group. Further, it would be interesting to investigate the length of the exercise effects on cravings after people leave the laboratory and consequently the length of time until they smoked their first cigarette.

### **6. 0.1. Aims and Hypotheses**

The purpose of the present study was to replicate Study 3 by examining the effects of exercise in non-abstinent smokers.

The present study will examine the following hypotheses:

***Hypothesis 7:*** Exercise will attenuate increases in cravings and withdrawal symptoms, elicited by the presence of a lit cigarette, in comparison to a passive control group.

***Hypothesis 8:*** The time participants have their next ad libitum cigarette, after leaving the laboratory, will be extended following exercise. Furthermore, cravings measures will be negatively associated with time to smoking the next cigarette.

## **6. 1 Materials and methods**

### **6. 1.1. Participants and procedures**

Following ethical approval from the University Research Ethics Committee, smokers were recruited through public advertisements. They were eligible for the study if there were no contraindications for moderate intensity exercise, and they had smoked at least 10 cigarettes daily for the past 3 years. Participants were screened for medical reasons (see

## Chapter 6: Study 4

appendix 1) and were asked to abstain from caffeine intake and exercise for two hours prior to a visit to the laboratory. They were also asked to bring a packet of their favourite cigarette brand and a mobile phone to the session.

Upon arrival at the laboratory, participants were given verbal and written information about the study and then they provided informed consent (see appendix 11). Participants were then given a cigarette of their usual brand to smoke in order to avoid variation on the abstinence level prior to the study.

Measures of weight, height, resting heart rate and systolic and diastolic blood pressure (SBP/DBP) (Digital BP Monitor Model UA-767PC, A & D Instruments) were taken, and body mass index (BMI) calculated, to provide descriptive data for the sample. Self-reported nicotine dependence was assessed using the Fagerström Test for Nicotine Dependence: FTND (Heatherton et al., 1991) (see appendix 4). Physical activity was assessed using the self-report 7-day recall measure, which has been shown to have acceptable validity and reliability (Blair et al., 1985) (see appendix 5).

In a within participants design, thirty participants were randomly assigned to either an exercise ( $n = 31$ ) or passive ( $n = 29$ ) group in a counterbalanced design to control for order effects. Participants were then fitted with a heart rate monitor (Advantage, POLAR) and taken into either a quiet room or in one with an exercise treadmill, depending on the condition they were assigned too.

### **6. 1.2. Treatment**

The current study adapted the same methodology to study 2, for more details please refer to study 2.

The mean (standard deviation) exercise intensity for walkers was subsequently calculated:

Heart Rate Reserve (HRR) = 30.79 (SD = 10.55); mean Rating of Perceived Exertion (RPE) = 11.62 (SD = 1.62) (i.e., 'fairly light').

### **6. 1.3. Dependent measures**

The current study used the same dependent measures to study 3, for more details please refer to study 3.

Cronbach's alpha for cigarette cravings ranged between .72 and .91.

Cronbach's alpha for withdrawal symptoms ranged between .70 and .91.

#### ***Additional measures:***

Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Heart Rate (HR) and

Mean Arterial Pressure (MAP) The current study adapted the same methodology, to study 3, for more details please refer to study 3.



## 6. 2 Results

Baseline characteristics for both exercise and control groups are shown in Table 6.1.

ANCOVA's (controlling for order) revealed that order of treatment had no influence on the effects of exercise  $F(1, 27) = .31, p = .58$  (Cohen's  $d = .66$ ). ANCOVA's (controlling for order) also revealed that responses to the lit cigarette were not influenced by order,  $F(1, 28) = .19, p = .66$  (Cohen's  $d = .52$ ).

	Session involving Exercise (n=30)	Session involving Passive control (n=30)
	$\bar{x}$ (SD)	$\bar{x}$ (SD)
Age (years)	25.8 (2.1)	
sex	19 males, 11 females	
FTND score	3.76 (2.06)	
Order, no of people starting with the exercise and control conditions	14 (8 males, 6 females)	16 (11 males, 5 females)
Hours of moderate or vigorous intensity physical activity	5.1 (2.1)	4.9 (1.9)
No. cigarettes smoked	15.6 (5.2)	
Heart rate	71.8 (9.2)	74.6 (10.6)
Systolic blood pressure	125.0 (9.3)	126.8 (8.3)
Diastolic blood pressure	74.4 (8.2)	71.8 (7.2)
Height (m)	1.7 (5.3)	
Weight (kg)	75.4 (10.5)	
BMI (kg/m * m)	25.6 (3.2)	
Withdrawal symptoms	1.6 ( .6)	1.7 ( .5)
Cravings	2.7 (1.6)	2.9 (1.6)

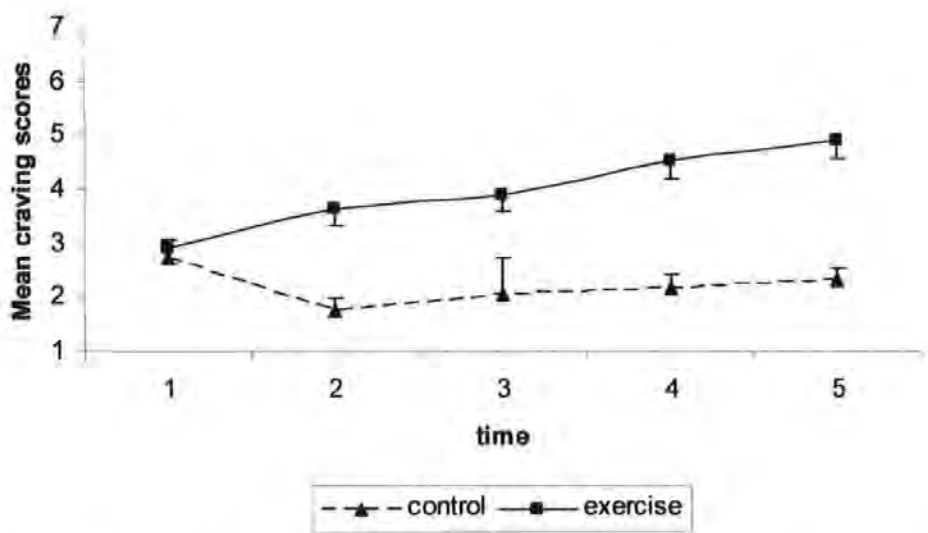
**Table 6. 1:** *Baseline characteristics of study participants in the exercise and passive control condition.*

***Preliminary analyses***

To examine the effects of exercise on cravings and withdrawal symptoms a 2 (exercise: walking, passive) x 5 (cravings: Times 1, Time 2, Time 3, Time 4, Time 5) x 5 (withdrawal symptoms: Times 1, Time 2, Time 3, Time 4, Time 5) MANOVA was conducted with exercise, cravings and withdrawal symptoms as within participants factor. Results supported a statistically significant 2-way interaction effect between time and exercise on cravings,  $F(2.8, 76.1) = 11.1, p < .01$  (Cohen's  $d = 0.9$ ), and withdrawal symptoms,  $F(2.5, 73.6) = 5.6, p < .01$  (Cohen's  $d = 0.5$ ), with a Greenhouse-Geisser correction. Planned contrasts revealed that at each time point, compared to baseline, the exercise group had significantly lower scores, for cravings and withdrawal symptoms ( $p < .01$ ) than the control condition; this is also illustrated in Figures 6.1 and 6.2.

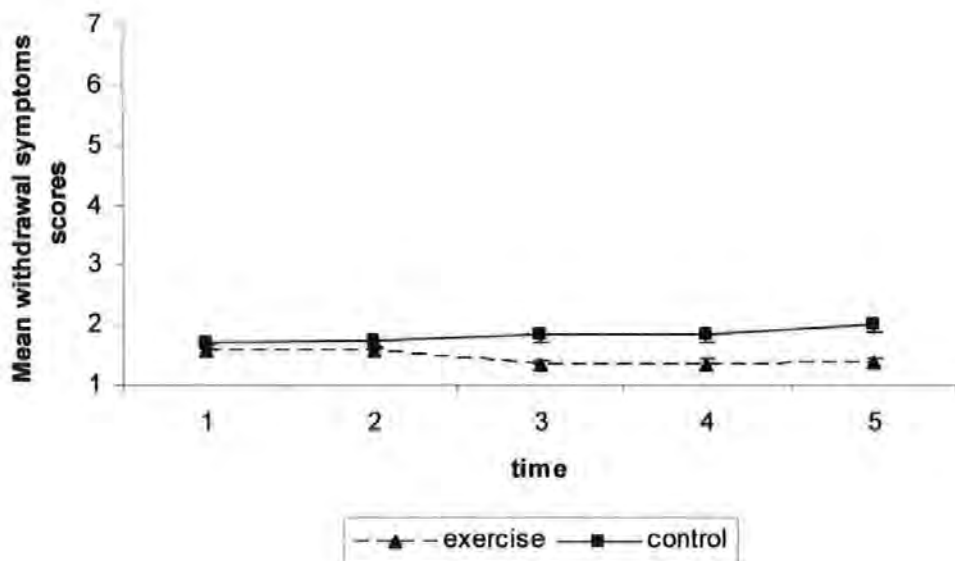
Moreover, in order to check whether the smoking status of the participants and their previous physical activity could control the effects of exercise on levels of cravings and withdrawal symptoms a 2 (exercise: walking, passive) x 5 (cravings: Times 1, Time 2, Time 3, Time 4, Time 5) x 5 (withdrawal symptoms: Times 1, Time 2, Time 3, Time 4, Time 5) ANCOVA was conducted with number of cigarette smoked daily and levels of physical activity as covariates. Results of the ANCOVAs when controlling for number of cigarettes smoked daily revealed non-significant interaction effects for levels of cravings  $F(4, 9) = .45, p = .77$  and partial  $\eta^2$  values decreased considerably from .24 to .16; and levels of withdrawal  $F(4, 9) = 1.06, p = .43$  and partial  $\eta^2$  values decreased considerably from .43 to .32. This finding suggests that the smoking status of the participants could control the effects of exercise on cravings and withdrawal.

When controlling for participant's levels of physical activity results of the ANOVAs significant interaction effects were still observed which means that the physical activity levels of the participants do not control the effects of exercise on levels of cravings and levels of withdrawal symptoms.



**Figure 6. 1:** *Changes in cravings in the exercise and control conditions, and pre and post smoking cue.*

*Notes: Time: 1 (pre-treatment); 2 (mid- treatment); 3 (end- treatment); 4 & 5 (pre- and post-lit cigarette).*



**Figure 6. 2:** *Changes in withdrawal symptoms in the exercise and control conditions, and pre and post smoking cue.*

*Notes: Time: 1 (pre-treatment); 2 (mid- treatment); 3 (end- treatment); 4 & 5 (pre- and post-lit cigarette).*

### 6. 2.1 Effects of exercise on cravings and withdrawal symptoms, elicited by the smoking cue

To test hypothesis 7 concerning the effects of exercise on withdrawal symptoms and cravings after the presentation of the lit cigarette a 2 (exercise: walking, passive) x 2 (lit cigarette: time 4, time 5) MANOVA was conducted using exercise and lit cigarette as a within-participants factor and cravings or withdrawal as depended variables. Results from these analyses did not reveal statistically significant interactions between exercise and lit cigarette on cravings or withdrawal symptoms. This mean that the walk did not attenuate increases in cue elicited cravings and withdrawal symptoms  $p > .05$ .

Table 6.2 displays participants' mean scores for cravings and withdrawal symptoms across the 5 time points. In this table, time points 4 and 5 are the time points where cravings and withdrawal symptoms have been measured after exercise and the lit cigarette have been administered. As a result, these are the time points that will show whether the stressor attenuated (diminished) the positive effects of exercise on cravings and withdrawal symptoms. As shown in this table, levels of withdrawal symptoms were lower throughout the experimental session for those participants who exercised. Further, although after the administration of the lit cigarette (at time 5) levels of cravings and withdrawal symptoms increased in both groups, these levels, on both cravings and withdrawal symptoms, were significantly lower for the participants who undertook the walk. Therefore although exercise did not attenuate cue elicited cravings and withdrawal symptoms, the effects of exercise on cravings and withdrawal symptoms are resistant to the smoking stressor.

		Baseline (T1) $\bar{x}$ (SD)	Mid-exercise (T2) $\bar{x}$ (SD)	Post-exercise (T3) $\bar{x}$ (SD)	Pre-lit cigarette (T4) $\bar{x}$ (SD)	Post-lit-cigarette (T5) $\bar{x}$ (SD)
<b>Cravings</b>						
	<i>Exercise</i>	2.7 (1.7)	1.8 (1.3)	2.1 (1.4)	2.3 (1.4)	2.5 (1.4)
	<i>Control</i>	2.9 (1.6)	3.7 (1.7)	3.9 (1.5)	4.6 (1.8)	5.0 (1.6)
<b>Withdrawal</b>						
	<i>Exercise</i>	1.6 ( .6)	1.3 ( .4)	1.3 ( .4)	1.3 ( .4)	1.4 ( .8)
	<i>Control</i>	1.7 ( .5)	1.7 ( .6)	1.8 ( .6)	1.8 ( .7)	2.0 ( .8)

**Table 6. 2:** *Effect of exercise on cravings and withdrawal symptom and responses to holding a lit cigarette.*

### 6. 2.2. Effects of exercise on *ad libitum* smoking behaviour

To test hypothesis 8, the mean time after leaving the facility before smoking the first cigarette was calculated and compared the differences between exercisers and non-exercisers. Correlations were also conducted in order to test whether overall craving scores and withdrawal symptoms at the final assessment were associated with the time to *ad libitum* smoking. The mean time after leaving the facility before smoking the first cigarette was 3.21 hours (SD = 4.77) for the group who exercised in comparison with 6.64 hours (SD = 1.24) for the non exercisers,  $F(1, 13) = 6.6, p < .05$  (Cohen's  $d = 0.6$ ). Cravings and withdrawal symptoms at the final assessment were both not associated with the time to *ad libitum* smoking (cravings:  $r = 0.18, p = .32$ ), withdrawal:  $r = 0.14, p = .46$ ). In support of hypothesis 8, exercise extended the time that people smoked their first cigarette after leaving the laboratory.

#### *Additional analysis*

Although a detailed analysis was beyond the scope of the present investigation, we examined the effects of exercise on blood pressure (BP) and heart rate (HR) pre and post the presentation of the lit cigarette in order to examine whether the effects of the smoking cue resulted on physiological reactivity. Using a 2 (exercise: walking, passive)  $\times$  2 ( lit cigarette: pre, post) with BP or HR as a within participants factors controlling for baseline BP or HR there were not any significant interaction effects  $p > .5$ , which means that the cue did not induce levels of physiological arousal/stress. Therefore, self-reporting levels of cravings and withdrawal symptoms were not associated with physiological arousal.

In addition, we conducted correlations in order to examine the relationship between cravings and withdrawal symptoms both cross-sectionally and in terms of change in response to the treatment. Cross-sectional correlations between cravings, and withdrawal symptoms were determined at each time point that they were measured (T 1- T5). Also change scores (between baseline and post the presentation of the lit cigarette, T1-T5) were calculated and correlations between these scores were determined. The results of the analysis revealed that levels of cravings were associated with levels of withdrawal symptoms, at baseline and also pre and post the presentation of the lit cigarette (see table 6.3). Reductions in levels of cravings were also associated with reductions in levels of withdrawal symptoms between baseline and the end of the session.

Correlation between cravings and withdrawal ( T1)	Correlation between cravings and withdrawal (T2)	Correlation between cravings and withdrawal (T3)	Correlation between cravings and withdrawal (T4)	Correlation between cravings and withdrawal (T5)	Correlation between change in cravings and change in withdrawal (from T1-T5)
.65**	.30	.31	.45**	.39*	.54**

**Table 6. 3:** *Correlations between cravings and withdrawal, Cross-sectional (from T1-T5) and change (from T1-T5) correlations between cravings, and withdrawal symptoms. \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$ .*

*Notes Time: T1 (pre-treatment); T 2 (mid- treatment); T 3 (end- treatment); T4 &T 5 (pre- & post lit cigarette).*



### 6. 3 Discussion

Study 4, was the first study to examine the effects of exercise on cue elicited cravings and withdrawal symptoms with non-abstinent smokers. The results of the study compare favourably with other research in the area of exercise and smoking cessation by showing that walking has a beneficial effect in reducing cravings and withdrawal symptoms and that the effects are resistant to the smoking cue. Furthermore, when participants had the freedom to smoke in the natural environment, exercise led to a net greater time of 3.21 hours before smoking in comparison with the control.

Hypothesis 7 predicted that exercise will attenuate increases in cue-elicited cravings and withdrawal symptoms, in comparison to a passive control group, among non-abstinent smokers. Results rejected hypothesis 7 by showing that exercise did not attenuate these increases. However, planned contrasts revealed that for those participants who undertook exercise, levels of cravings and withdrawal symptoms were significantly lower after the presentation of the lit cigarette, in comparison to the control condition.

Results of the additional analysis revealed that the smoking cue induced self-reported levels of cravings and withdrawal (especially in the control group) but it did not induce physiological arousal. This finding compared favorably with findings of study 3 but it is contrary to the findings of study 2. The findings of study two suggested that although the stressors used in the study (stroop and speech tasks) induced physiological arousal, this was not associated with increases on the self-reported measures of cravings and withdrawal symptoms.

If increased stress is associated with increased cravings to smoke, it seems that the smoking cue increases tobacco appetite not because of induced physiological arousal/stress but probably due to induced negative affect associated with not being able to smoke (Niaura et al. 1988, 1992, 1998; Carter and Tiffany 1999; Hutchison et al. 1999; Tiffany et al. 2000; Sayette et al., 2001). This is further supported by studies that have shown that smoking related cues are more efficient in eliciting smoking related cravings and withdrawal symptoms than neutral cues (Carter & Tiffany, 1999; Shadel et al., 2001). It is worth noting that the present studies are still at a preliminary level, therefore future studies should be conducted considering stress indicators, other than BP, that might be more sensitive, e.g. cortisol levels.

Moreover, the results of the correlations between levels of cravings and withdrawal symptoms revealed that levels of cravings and levels of withdrawal symptoms are positively associated. This further supports the speculation of Kelly et al., (2004), that the autonomic responses of cigarette cravings may be dependant on the perceived reinforcing value of cigarettes.

Hypothesis 8 predicted that exercise will increase the lag time to the next cigarette. Furthermore, craving measures would be negatively associated with time until smoking the next cigarette among non-abstinent smokers. In support of hypothesis 8, when participants had the freedom to smoke in the natural environment, exercise led to a net greater time of 3.21 hours before smoking, in comparison to the control. The length of time between cigarettes in this study is greater than the findings of studies 2 and 3 and has an important implication; it suggests that exercise can prolong smoking initiation in smokers who are not smoking abstinent and are not thinking about quitting. Also, although the present study was

not designed with this hypothesis in mind, it may be that physical activity may reduce the risk of progression from an occasional smoker to a dependent smoker (see Audrain-McGovern, Rodriguez & Moss, 2003). Therefore exercise could be used as a proactive aid for those smokers who wish to cut down on their smoking.

In summary, the findings of the study reveal the potency of the smoking cue (the presentation of a lit cigarette) to induce cravings in non-abstinent smokers and supports the relapse-preventing efficacy of exercise on ad libitum smoking behaviour. Overall, the results of the present study show that a 15 minute walk eases cravings and withdrawal symptoms in non-abstinent smokers and that the effects are resistant to the smoking cue. Furthermore, walking can prolong the time between cigarettes in non-abstinent smoke.

## **Chapter 7**

### **7. 0 General Discussion**

Overview of studies 1-4

study	aims	methods	sample	Summary of findings	Contribution to thesis
1	Exercise will 1) Reduce cravings and urges to smoke. 2) Reduce emotional stress and induce activation. 3) enhance positive affect 4) Cravings and urges mediated though mood and affect 4) Exercise effects will last for 20 min after the exercise.	Self paced one-mile walk: HRR= 24.5% (7.6) VS passive control  Smoking abstinence: 15 hrs  Within subjects counterbalance design.	15 smokers  Age: 25.6 (6.5)  Smoking: 16.6(10.6)  FTND: 4.0 (3.1)	Exercise reduced levels of cravings and urges to smoke.  After exercise participants experienced a state of calmness and relaxation.  Cravings and urges to smoke were mediated by reduced tension.	Preliminary investigation of the underlying mechanisms of the effects of exercise on cravings, urges and mood through the investigation of affect.  Length of exercise effects.
2	Effects of exercise on cravings and withdrawal symptoms under conditions of stress and the presence of smoking cue.  Lag time to the next cigarette	15 min self paced walk: HRR= 24.1% (5.1) VS passive control.  Smoking abstinence: 2 hr  Randomized between subjects blind design	60 smokers.  Age: 30.1 (9.7)  Smoking: 15.0 (7.8).  FTND: 3.5 (2.2)	Exercise attenuated increases in levels of cravings and withdrawal symptoms under conditions of stress and the presence of smoking cue.  Lag time to the next cigarette: 57 min	A preliminary investigation of the effects of exercise on levels of cravings under conditions of stress and the presence of smoking cue.  Examination of the lag time to the next cigarette
3	Effects of exercise on cue elicited cravings and the lag time to the next cigarette	15 min self paced walk: HRR= 37.3% (6.1) VS passive control.  Smoking abstinence: 2 hr  Within subjects randomized counterbalanced design	30 smokers  Age: 21.86 (2.09)  Smoking: 25 (13.7)  FTND: 8 (3.5)	Exercise attenuated increases in levels of cue elicited cravings and withdrawal symptoms.  Lag time to the next cigarette: 35 min	Further investigation on the effects of exercise on cue elicited cravings using a different design than study 2.  Examination of the lag time to the next cigarette
4	Effects of exercise on cue elicited cravings and the lag time to the next cigarette.	15 min self paced walk HRR= 30.79% (10.55); VS passive control.  Smoking abstinence: none  Within subjects randomized counterbalanced design	30 smokers  Age: 25.8 (2.1)  Smoking: 15.6(5.2)  FTND: 3.76 (2.06)	Exercise attenuated increases in levels of cue elicited cravings and withdrawal symptoms.  Lag time to the next cigarette: 3.21 hrs	Investigation of the effects of exercise on cue elicited cravings and the lag time to the next cigarette in non-abstinent smokers.

Table 7. 1: Overview of studies 1-4

Note: For list of abbreviations please refer to Appendix 13.

The purpose of the current thesis was to examine the effects of self-paced walking on cigarette cravings and withdrawal symptoms amongst temporary smoke-deprived and non-deprived smokers. A unique contribution of the present studies is concerned with investigation of the extent and the duration of the exercise effects and whether these effects could be resistant to smoking cues known to elicit a strong desire to smoke. In addition, the present studies are the first to demonstrate the duration of the exercise effects after participants leave the laboratory and have the freedom to smoke. Moreover, the present investigation provides a preliminary investigation of the underlying mechanism of the effects of exercise on smoking. The present thesis investigated the effects of exercise on affective states through the circumplex model of affect that examines affective valence and activation. The results indicated that exercise has a dual effect on affect. During exercise there is an increment on positive valence and activation and a reduction on levels of stress. After exercise although affective valence remains high levels of activation drops which means that participants are experiencing a level of calmness and relaxation. This is very important because when people are in a state of calmness then they are less reactive to stressors, which makes them less likely to smoke (Cohen & Lichenstein, 1990; Robinson & Pritchard, 1992; Schachter, 1978).

### **7. 0.1. Effects of exercise on cravings and withdrawal symptoms**

Results of all the studies in the present thesis indicated that a self-paced walk reduced cravings and withdrawal symptoms in comparison to an equal passive control condition. These findings are in line with findings of previous research (Pomerleau et al. 1987; Thayer et al. 1993; Bock et al. 1999; Ussher et al. 2001; Daniel et al. 2003). Previous studies had demonstrated that forced-moderate intensity exercise for ten minutes in the form of indoor

cycling reduced cravings, withdrawal symptoms and promoted positive affect. In these studies the effects of exercise lasted for at least 10 minutes post exercise (Ussher et al., 2001). Results of the studies 1- 4 replicated their findings when using longer duration exercise in the form of walking at self selected intensity. Furthermore the present studies extended previous findings by showing that the effects of exercise could last for at least 20 to 50 minutes following exercise. These findings are innovative as it is the first time that low- to moderate-intensity exercise (such as a self-paced brisk walk) has been shown to have such effects.

When reviewing previous studies, it became evident that the measurement of psychological states and cravings has been atheoretical and were assessed with single item measures (e.g. MPSS) (Bock et al., 1999; Daniel et al., 2006; Daniel et al., 2004; Everson et al., 2006; Pomerleau et al., 1978; Thayer et al., 1993; Ussher et al., 2001, 2006). According to Shiffman (2004), based on psychometric principles, multiple item measures of cravings and withdrawal are likely to perform better than single item measures. The present investigation considered these methodological shortcomings of previous studies. More specifically, in study 1 it was hypothesized that exercise would reduce levels of cravings and negative mood, by employing both multiple and single measures of mood, affect and cravings. The effects of exercise on smoking were also measured for at least 20 minutes following exercise. Findings of the study showed that walking reduced cravings and negative mood such as tension during exercise and for at least 20 minutes after exercise. These findings were consistent with both single and multiple item measures. This provides greater reliability for the findings of previous studies that used single item measures (Bock et al., 1999; Daniel et al., 2006; Daniel et al., 2004; Everson et al., 2006; Pomerleau et al., 1978; Thayer et al., 1993; Ussher et al., 2001, 2006) while adding to the evidence for length of

possible effects. It is also worth noting that the effect size (even at 20 minutes post-exercise) for cravings ( $d = 1.9$ ) was larger than previously reported by Daniel et al., (2004) and Ussher et al., (2001) in any time point of their studies.

### **7. 0.2. Mechanisms explaining the effects of exercise on cravings and withdrawal symptoms**

Another unique contribution of the present investigation is the explorations of mechanisms responsible for the exercise effects. Although previous studies in the area of exercise in smoking cessation reported the beneficial effects of exercise on smoking withdrawal outcomes, they did not attempt to explore the mechanism responsible for these effects. If a plausible mechanism could be shown then this could add support for a causal effect, and extend understanding of how exercise can affect smoking withdrawal outcomes.

The present investigation aimed to explore whether exercise can affect smoking withdrawal outcomes, such as mood and cravings, because it can mimic the effects of smoking. Given the evidence that smoking may act as a stimulant and relaxant (see Parrott, 1998 for a review), Study 1 examined whether exercise could mimic the effects of smoking by inducing feelings of relaxation and activation by increasing arousal (energy) and reducing emotional stress (tension) (known as Nesbitt's paradox).

Furthermore, it was examined whether the effects of exercise on cravings and urges will be mediated by changes in tension, affective, valence and activation.

Results of the Study indicated that although exercise reduced levels of tension it did not induce levels of activation. ANCOVAs, also suggested that reductions in cravings were mediated by reduced tension (emotional stress) while effects on urges were mediated by



## Chapter 7: General Discussion

affective activation (calmness). Increased energy, vigor (stimulation), or affective valence did not mediate cravings and urges. This is the first study in the area of exercise and smoking cessation to examine the mediating effects of mood on urges and to reveal such an effect. This finding has some important implications. It suggests that symptoms of stress (i.e., tension) can be reduced through exercising and will in turn be associated with reduced cravings for a cigarette. Stress has been associated with smoking relapse (Cohen & Lichenstein, 1990).

Conclusively, the findings of the present investigation suggest that exercise could mimic the effects of smoking by reducing tension (psychological stress) rather than increases in activation.

The fact that exercise did not produce the expected effects on levels of activation (arousal) may have been due to several reasons. First, the sample size was inadequate (for these variables). Second, the laboratory environment might have induced an elevation in arousal, thereby making the observation of change in response to exercise more difficult. Third, the specific measures of mood might have not captured exercise induced arousal. Before we can eliminate the potential value of exercise in mimicking the stimulating properties of a cigarette, further research is needed. Future studies should focus on how to manipulate low levels of arousal (e.g. induce states of boredom and a desire for stimulation) that, in other settings, may precipitate the need for stimulation from a cigarette.

Extensive research has confirmed that nicotine cravings are a function of the disruption of neurotransmitters, such as dopamine, in the pleasure and reward centers of the brain. Nicotine provides almost instant relief by increasing dopamine production. The present thesis implies that exercise reduces cravings, possibly through a similar mechanism

(Meeusen & De Meirleir, 1995). Since affective valence did not mediate change in cravings, it seems likely that exercise-related enhanced affective valence does not result from enhanced dopaminergic activity. Further study of the effects of exercise on smoking cravings, withdrawal symptoms, mood and affect may help to identify the psychobiological mechanisms involved in the exercise and mental health relationship.

In order to understand the pattern of changes in stimulation and relaxation, during exercise, it was decided to use the circumplex model. In the circumplex model the affective space is defined in terms of two dimensions of affective valence and perceived activation.

An advantage of using the circumplex is that it can disentangle changes in activation from changes in affective valence (Ekkekakis & Petruzzello, 2002).

The measurement of affect with the use of the circumplex model is a unique contribution of the present investigation. The use of this model was theoretically driven from the work of Parrott (1998) and Shiffman and colleagues (2004). Parrott (1998), after considering Nesbitt's paradox (an urge to smoke can be driven by the need for both stimulation and relaxation), Parrott (1998) suggested that a multidimensional understanding of affect is useful in understanding the pattern of changes in stimulation and relaxation. In specific, he proposed the use of a model in which changes in activation and valence can occur independently and the same time. Furthermore, Shiffman et al. (2004) urged researchers to consider general measures of affect to allow the results of smoking withdrawal studies to be integrated with other studies of affect. The circumplex model choice to measure affect was driven by the above recommendation of Parrott and Shiffman and by the fact that it was previously used in exercise studies to measure affect in non smokers. The circumplex model has never been used before in the study of exercise in smoking cessation.

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The results of the circumplex model as demonstrated in figure 3.3 suggested that a short bout of walking was associated with more pleasant affect which lasted up to 20 minutes following exercise. It was also demonstrated that exercise has a dual effect on activation. It increases activation, lasting until the end of exercise, following which; activation is reduced resulting in a feeling of calmness and relaxation. This is important because when people are in a state of calmness and relaxation they are less reactive to stressors, which make them less likely to smoke (Schachter, 1978). Schachter (1978) noted: "smokers widely report that they smoke more when they are tense or anxious and they also report that smoking calms them" (p. 209). Conclusively, the findings of the circumplex model suggest that, exercise could protect people from smoking by reducing levels of stress.

The results of the circumplex model in this study support previous research by Ekkekakis et al. (2000) with non-smokers. Ekkekakis and colleagues showed that short walks (10-15 minutes), were associated with increases towards activation and more positive affective valence in non-smokers. Their results also indicated that a 10-15 minute recovery from walking was associated with a return towards calmness and relaxation. This pattern reported by Ekkekakis et al. was robust across different self-report measures of the circumplex affective dimensions, across different ecological settings (field and laboratory), across time, and across samples.

### **7. 0.3. Effects of exercise on cue-elicited cravings**

Study 2, 3 and 4 pioneered in examining cue elicited cravings. In these studies participants, who walked or waited passively, were exposed to smoking cues, during the following up period, known to elicit strong cravings. Results of all three studies revealed that walking reduced levels of cravings and withdrawal in comparison to the control condition, and the effects of exercise were resistant to stressors.

Furthermore, the studies examined above predicted that a 15 minute walk will attenuate increases in cue elicited cravings and withdrawal symptoms in comparison to the control.

In Study 2, during the follow-up period participants were exposed to two cognitively-demanding tasks (Stroop and speech task) and a smoking cue (the presentation of a lit cigarette). These tasks were used to elicit cravings to smoke. The results of the study revealed statistically significant interactions between exercise and the lit cigarette on withdrawal symptoms but not cravings.

In order to further determine and identify the efficacy of the lit cigarette cue in smoking cravings, Study 3 was conducted. Identifying the potency of a smoking cue to elicit cravings is important in order to further examine the relapse-preventing efficacy of exercise.

Results of study 3 compared favourably with study 2 revealed that walking attenuated increases in cravings and withdrawal symptoms responses to the lit cigarette cue, in comparison to the participants who undertook the passive control condition. Furthermore, exercise did not attenuate increases in cue elicited cravings or withdrawal symptoms. An explanation of these findings is that in both studies, levels of cravings (especially prior to

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the presentation of the lit cigarette) were high, reaching a ceiling effect which limited the scope for observing cue-elicited cravings.

On the other hand, contrary to Study 2, results of Study 3 revealed that exercise did not attenuate increases in levels of withdrawal symptoms in comparison to the control group.

The controversy of the findings on the effects of exercise on cue elicited withdrawal symptoms could be explained if one considers that participants in Study 2 (before the presentation of the lit cigarette) were smoking abstinent for a longer period than participants in Study 3. Furthermore, they had also been exposed to two additional stressful situations (Stroop and speech task). Therefore, in comparison to Study 3, the longer smoking abstinence and the accumulative effects of the stressors, induced high levels of withdrawal discomfort, prior to the presentation of the lit cigarette (to participants who undertook the control condition). On the other hand in Study 3 the brief 2 hour smoking abstinence, prior to the study, was not sufficient to induce levels of withdrawal symptoms. As a result, the participant's low levels of withdrawal discomfort influenced cue elicited changes. Research has demonstrated that the level of withdrawal discomfort that an individual may experience varies and depends on a number of factors such as, the length of smoking abstinence, the individual's smoking status, the environment that the smoker is exposed to and also on other situational cues (Parrott, 1998). It may be that a longer smoking abstinence period prior to the study, or exposure to stressful situations (such as in Study 2), may have resulted in higher levels of withdrawal symptoms. However this could risk reaching a ceiling effect on cravings thereby leaving less scope for a cue elicited change

In order to further examine the effects of exercise on cue elicited cravings induced by the lit cigarette Study 4 was conducted. Study 4 involved non-abstinent smokers. This intervention involving non-abstinent smokers has not been used before in the study of exercise and smoking. By examining the effects of exercise among non-abstinent smokers, Study 4 controls for unrealistically high levels of cravings and examines the potency of the smoking cue. Research suggests that even non-abstinent smokers could show reactivity on craving levels when they are exposed to smoking cues. This is because the autonomic responses of cigarette cravings may be depended on the perceived reinforcing value of cigarettes, which can be modulated by smoking abstinence (Kelly, Barrett, Pihl & Dagher, 2004). Furthermore, it is important to explore the effects of exercise in cue elicited cravings in smokers, during different periods of smoking abstinence and not abstinence, in order to examine the relapse-preventing efficacy of exercise. Recognizing the condition of the smoker is a critical determinant in cravings response and can identify the relapse-preventing efficacy of exercise.

Results of study 4 suggested that exercise did not attenuate increases in levels of cravings or withdrawal symptoms in comparison to the control group. However, results of the planned contrasts revealed that for those participants who took part in the exercise condition, levels of cravings and withdrawal symptoms were significantly lower after the presentation of the lit cigarette, in comparison to the control condition. The results of this study confirm the potency of the smoking cue to elicit cravings and shows that walking can suppress levels of withdrawal symptoms and cravings in comparison to the control condition.

Overall the results of present studies indicated that the effects of exercise are resistant to smoking cues. In the present studies the presentation of the lit cigarette cue that people were allowed to handle, but not smoke, was used as a cue to elicit cravings. The findings of the present studies confirmed the potency of the lit cigarette cue to elicit cravings. A number of experimental studies have indicated that exposure to smoking related cues, in comparison to non-smoking related cues, markedly increases craving for tobacco and may induce stress (and negative affect) associated for not being able to smoke (Niaura et al. 1988, 1992, 1998; Carter and Tiffany 1999; Hutchison et al. 1999; Tiffany et al. 2000; Sayette et al. 2001). This could further explain why in Study 2, the Stroop and speech tasks did not induce cravings to the people who undertook the control condition. Most importantly by examining the potency of the smoking cue in both abstinent and non-abstinent smokers we demonstrated that the particular cue is potent to elicit cravings in all smokers independently of their smoking status. Furthermore, it was demonstrated that walking is an effective aid to combat cravings for all smokers at all stages of smoking abstinence. This has an important implication, it suggests that exercise could be used as a relapse prevention strategy by smokers who either want to quit or who just want to cut down on their smoking. Overall, the results of the present investigations confirm the relapse prevention efficacy of exercise.

### **7. 0.4. Mechanism explaining the effects of exercise on cue-elicited cravings**

According to the findings of the present studies we attempted to further explore the mechanism of the exercise effects on cue elicited cravings. Stress has shown to increase cravings and withdrawal symptoms and contribute to relapse during attempts to quit (West, 2001). Given that the effects of exercise are resistant to stressors (as shown in Studies 2, 3 and 4), one may expect that stress elicited cravings and withdrawal symptoms may be

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attenuated by exercise. In the present studies it was found that a brisk walk attenuated stress induced increases in the subjective responses of cravings only after the lit cigarette cue but not after the presentation of mentally challenging tasks (stressors) (see Study 2). Additional analysis on blood pressure and heart rate indicated that the stressors induced physiological arousal in the control condition, therefore they induced physiological stress. Nevertheless, the physiological stress was not associated with the self reported levels of cravings and withdrawal symptoms. In contrary, results of studies, three and four, indicated that although after the presence of the lit cigarette, levels of self-reported cravings and withdrawal symptoms were increased, especially in the control condition, these effects were not supported by heightened physiological arousal.

In Studies 2 and 4 it was also shown that levels of cravings were positively correlated with levels of withdrawal. Therefore, the results of the present studies suggest that cue elicited cravings are not generated because of induced physiological arousal/stress, but possibly due to the negative affect associated for not being able to smoke (Kelly et al, 2004). Other more potent, experimental and natural stressors could be used that typically trigger cravings to explore further the effects of exercise.

In summary, there is some evidence that exercise reduces cravings by its effects on negative affect or psychological stress. However, further research is needed to assess the involvement of other psychological and physiological stress markers (e.g. heart rate variability, cortisol, eye movement and attentional bias), perhaps even involving more challenging tasks.



### **7. 0.5. Effects of exercise on Ad libitum smoking behaviour**

Another unique contribution of the present investigations is the investigation of the time that people smoke their first cigarette after leaving the laboratory and are exposed to their natural environment, where they have the freedom to smoke (ad libitum smoking). This is an important element of the design of the studies because it allows for a more accurate reflection of potential ratings of cravings and withdrawal symptoms in a 'real life' abstinence attempt, away from a laboratory setting. Another innovation is the use of text messaging by cell phone to assess the effects of exercise on ad libitum smoking.

As shown in studies 2, 3 and 4 walking extended the lag time to the next cigarette in comparison to the control by 57minutes, 35minutes and 3.21 hours respectively. These findings compare favourably with the findings of a previously published study (Thayer et al., 1993) that showed that, in a naturalistic setting, five minutes of exercise (walking) extended the time to ad libitum smoking by an average of eight minutes and by one unpublished laboratory study (Reeser, 1983) that showed that 10 minutes of cycling increased ad libitum smoking by 24 minutes. These studies however had limitations. The precise dose of exercise was unclear in the Thayer et al study. In addition, the environment which participants exercised and filled in questionnaires was not controlled and therefore is not certain that was free of distractions and social interaction which may have affected the results. In Reeser's study the laboratory follow-up period where participants were free either to smoke or read may have interfered with ad libitum smoking.

In order to overcome the limitations of previous research, studies two, three and four used more rigorous experimental designs and a controlled experimental environment.

Furthermore, studies 2, 3 and 4 extended findings of previous research by exposing participants to stressors and a smoking cue, during the follow up period. The results of the

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studies suggested that exercise extended the time lag to the next cigarette even when participants were exposed to stress.

The variation across studies 2, 3, and 4 and across studies by Thayer and Reeser, in net delay to ad libitum smoking (as a result of exercise) is not easy to explain as all the studies involved different designs. The fact that the study by Reeser involved heavier smokers (mean cigarette= 23 per day) and a moderate –vigorous exercise intensity , compared with studies 2, 3 and 4 where participants smoked on average 15 cigarettes daily and a low – moderate exercise intensity, may account for a shorter net effect of exercise on smoking behaviour.

Vigorous exercise when compared to less intensive exercise may elicit a stress response (due both to physiological demands and cognitive threat appraisals) that could have less positive effects on smoking behaviour and cravings (Taylor et al., 2007). The difference in the lag time to the next cigarette between Studies 2 and 3, is still not easy to explain.

Although in Study 2 participants were exposed to more stress than those in Study 3, and although they remained smoking abstinent for longer time, their lag time to the next cigarette was longer than in Study 3, 57 minutes (Study 2) and 35 minutes (Study 3). This difference in the lag time to the next cigarette may be due to the fact that participants in Study 3 responded to a greater intensity exercise (HRR= 37.3%; RPE =12.2) than those in Study 2 (HRR=24.1%; RPE=10.9), and therefore this may have effected their post exercise experience. It was also shown from the Fagerström Test for Nicotine Dependence, FTND scores (Heatherton et al., 1991), as well from the number of cigarettes smoked daily, that participants in Study 3 were heavier smokers, FTND = 8 (3.5) and smoked on average 25 (13.7) cigarettes daily, in comparison to those participants in Study 2, FTND scores = 3.9

(2.3) and smoked on average 15.0 (7.8) cigarettes daily. This is further supported from the results of the ANCOVAs in studies 2–4 that have indicated that the smoking status of the participants could control the effects of exercise on levels of cravings and withdrawal symptoms. Therefore, from these findings one can conclude that the effects of exercise on the lag time on the next cigarette is also depended on participants smoking status. Future studies are warrant to investigate further the effects of exercise on the lag time to the next cigarette in light and heavy smokers

The longer net lag time in Study 4 could be attributed to the fact that participants were not smoking abstinent at baseline and has an important implication. It shows that exercise can prolong smoking initiation in smokers who are not smoking abstinent and are not thinking about quitting. This finding complements previous research that has consistently reported that physically active people are less likely to smoke or smoke fewer cigarettes (e.g., Boutelle, Murray, Jeffery, Hennrikus & Lando, 2000), and emerging evidence that suggests that physically active adolescents are less likely to progress to be regular smokers (Audrain-McGovern, 2003). These relationships may be explained in a number of ways, including the possibility that exercise has positive mental health benefits that mediate the appetite for substance use or a self-image as a healthy person.

Overall, the results of the studies suggested that exercise increases the lag time to the next cigarette. Examining the lag time to next cigarette has an important implication. Extending the period between cigarettes may have the potential to reduce the number of cigarettes smoked in a day, thereby resulting in harm reduction (deRuiter & Faulkner, 2006). The small but significant correlation between measures of cravings at the final laboratory

assessment and time to ad libitum smoking in Studies 2 and 3 supports the predictive utility of the craving measures used in these and also in previous exercise studies.

### **7. 0.6. Methodological design**

Previous studies in the area used between-participants designs (all involving randomized control trials) (Bock et al., 1999; Daniel et al., 2006; Daniel et al., 2004; Everson et al., 2006; Pomerleau et al., 1978; Thayer et al., 1993; Ussher et al., 2001, 2006). Studies one, three and four (in the present thesis) extended methodologically previous studies by using within participants counterbalanced designs. This was used to examine the effects of exercise on urges to smoke at the intra-individual level. Furthermore, Study 2 used a blind randomized between participants design in order to eliminate experimental bias and examine whether the non blinding experimental designs used in previous studies might have elevated the strength of effects. Such an experimental design enhances experimental rigor across the studies. Given the relatively small number of studies conducted in the area and the heterogenous doses of exercise across these studies, it is probably premature to consider the impact of methodology on the findings. Although the present line of research it is still at its infancy, nevertheless the effects of acute exercise on smoking cessation outcomes were replicated in all the studies despite of the research design they used.

### **7. 0.7. Effects of exercise on active and sedentary smokers**

The participants in all studies in this thesis were more physically active over the previous week than in the Daniel et al. (2004) and Ussher et al. (2001) studies. This suggests that the effects may be generalisable to both sedentary and considerably more active populations. Despite similar periods of deprivation and scores on the FTND (compared with the Daniel et al., 2004, and Ussher et al., 2001) (especially in Studies 1 and 2), scores on cravings and

mood appeared to drop to lower levels during and following exercise, relative to baseline, as well as remaining lower for a longer duration than reported in previous studies (Daniel et al., 2004; Ussher et al., 2001). It may be that physically active smokers are also more confident in an exercise setting and gain greater positive affect from the experience. Whilst, further studies may contrast the effects of exercise between active and inactive populations, ANCOVAs in studies 1-4 have indicated that previous levels of physical activity do not control the effects of exercise on cravings, withdrawal symptoms and affect.

### **7. 0.8. Effects of exercise on cravings and withdrawal symptoms after various smoking abstinent and non-abstinent periods**

Previous 'well-controlled' studies (Daniel et al., 2006; Daniel et al., 2004; Everson et al., 2006; Ussher et al., 2006; Ussher et al., 2001) have required about 15 hours of smoking abstinence to elevate urges to smoke prior to exercising in order to simulate deprivation, a commonly used paradigm in addiction research to test the effects of different interventions. The present investigations using various smoking abstinent periods as well as non-abstinence supported findings of these studies. Study 1 consistent with previous research used an abstinent period of 15 hours, both Studies 2 and 3 used an abstinent period of two hours while Study 4 used non-abstinent participants. The findings of all studies were consistent independently of the participants smoking abstinent period. This finding is important because it suggests that exercise could be used as a relapse prevention strategy at all stages of smoking abstinence. It suggests that exercise could be used as relapse prevention for smokers who are at the initial stages of quitting and experience great levels of cravings and withdrawal discomfort, but also it can be used by those smokers who just wish to cut down on their smoking. Nevertheless, these investigations were taken place in laboratory conditions, therefore before exercise could be recommended as an aid to

smoking cessation there is a need to examine whether its effects can be observed during real quit attempts, outside the laboratory, in naturalistic settings using real time assessments (Shiffman et al., 1996). While the present studies were not designed with this goal in mind, the design should be extended in order to understand the role of single sessions of exercise in naturalistic environments among people who are actually quitting and who are at different temporal stages in the attempt to quit.

### **7. 0.9. Efficacy of exercise to reduce cravings and withdrawal symptoms in comparison to other conventional treatments**

The findings of the present studies suggest that a self paced walk in laboratory settings can be recommended as a smoking cessation aid for regulation of cravings, withdrawal symptoms and negative affect. More importantly, it was shown that a brief session of walking is effective in attenuating cue elicited cravings and withdrawal.

It is worth noting that the magnitude of the reduction in cravings with exercise is encouraging and comparable with the acute responses to glucose and oral NRT (West et al, 1999; West et al., 2001). Also, exercise tends to show a more rapid effect on cravings and withdrawal symptoms when compared with studies of oral NRT (West et al., 2001). In one of the more rigorous studies, effects were not evident until 10 minutes after taking the nicotine gum, relative to the placebo (Shiffman et al, 2003). This finding is important because if one considers the psychobiology of nicotine addiction could see that the effects of exercise are comparable to the effects of smoking. Nicotine depletion can lead to a range of negative psychological states such as tension, irritability, nervousness. Cigarette reinstatement then generates a feeling of relaxation and pleasure (Parrott, 1998). The psychoactive effects of

smoking are rapid with mood increases accompanying each boost to the brain 7-10 sec post inhalation (Revel, 1988; Benowitz, 1990; Warburton, 1992). As shown in the present investigations a brief session of self-paced walk, in laboratory conditions, also has very rapid effects of mood, cravings and withdrawal symptoms in comparison to other conventional pharmacological aids used to combat cravings. Therefore for groups of quitters such as pregnant and post-partum smokers, many of whom may prefer not to use pharmacological agents (Ussher & West, 2003), exercise may serve as an aid to combat cravings and withdrawal discomfort.

### 7. 1 Limitations

Overall, the results of the present investigations suggest the relapse prevention efficacy of exercise. Exercise attenuated increase in levels of cravings and withdrawal symptoms and these effects were resistant to smoking cues. More importantly, the effects of exercise were replicated and were consistent for all smokers independent of their smoking abstinence period. In the present studies the presentation of the lit cigarette cue that people were allowed to handle, but not smoke, was used as a cue to elicit cravings.

Nevertheless, the present investigations were taken place under controlled laboratory conditions. In order to investigate further the effects of exercise on cue elicited cravings and generalise its effects, there is a need to examine the effects of acute exercise in different ecologically-valid, complex cues and specific complex cue situations and environments (e.g., social gatherings, bars) that are also shown to increase cravings. The use of visually presented smoking images (e.g. using virtual-reality software) may also be useful in order to extend the understanding of the usefulness of exercise as an aid to

## Chapter 7: General Discussion

smoking cessation (Lee et al., 2004). Additional research is also warranted to further investigate the efficacy of different doses of exercise (e.g., intensities and durations) on cue-elicited cravings in both laboratory and naturalistic environments.

The mechanism responsible for the effects of exercise has not been fully established yet. Therefore one may consider that the effects may be due to participant's expectancy bias which is an almost-inherent factor in studies of exercise (Berger et al., 1998). In the present thesis we tried to eliminate expectation by disguising the purpose of the experiments. Participants were informed that the studies examined heart rate responses in smokers during walking. Also if participants had expected exercise to have an effect on cravings and affective responses, then a more pronounced dilution of effects with time may have been expected. Nevertheless, it was not the direct aim of the present studies to examine expectation bias therefore research is warrant to further investigate whether the effects of exercise may be due to other reasons such as psycho-social or due to expectancy.

Distraction may also appear to be an obvious explanation for the effects of exercise especially in light of the control group. Although the scope of the present investigation was to not examine the distracting effects of exercise, nevertheless, the evidence does not support this possibility (Daniel et al., 2006). At a high intensity exercise above the 'ventilatory threshold' (Ekkekakis et al., 2006), may induce greater cognitive demand than in low intensities which may act as a distraction. There also may be some relatively low intensity exercises (e.g. yoga, tai chi) that demand increased cognitive focus. Ussher and colleagues (2006) reported that isometric exercise and a 'distracting scanning' control condition had similar effects on cravings. However the isometric exercise had relatively modest effects and this study requires replication. In other studies, following moderate



intensity cycling, there was a greater reduction in cravings and withdrawal symptoms when compared with a distracting task (in a control condition) (Daniel et al, 2006; Thayer et al, 1993). Finally, one may expect that if exercise reduces cravings and withdrawal symptoms due to distraction then a more pronounced dilution of effects with time may have been expected. The results of the present studies suggest that this does not appear to be the case. It would be difficult to see how the distracting effects of 15 minutes of light-moderate brisk walk could extend through the completion of two cognitively-demanding tasks and at the presence of a lit cigarette, as shown for example in Study 2. Nevertheless, although distraction does not appear to be the main mechanism by which exercise reduces cravings and withdrawal symptoms further studies, using different control groups are needed to examine further the distracting effects of exercise.

Studies 2, 3 and 4, are the first studies to assess the effects of exercise on ad libitum smoking with the use of text messaging by cell phone. However, one limitation of the present studies is that it was dependent on participant's self-reported smoking behavior and we were unable to observe whether smoking behaviour changed (e.g., more cigarette puffs when the cigarette was smoked) or what the physical activity level of participants during this time or even if participants were further exposed to smoking cues or stressors. Only two unpublished studies by Mikhail (1983) and Reeser (1983), reported on other measures related to this issue. Mikhail (1983) reported that two active conditions resulted in less time holding the next cigarette smoked, and Reeser (1983) reported that stretching/isometrics resulted in fewer puffs on the first cigarette smoked after exercise. Nevertheless, the small but significant correlation between measures of cravings at the final laboratory assessment and time to ad libitum smoking in Studies 2 and 3 supports the predictive utility of the craving measures used in these and also in previous exercise studies. Future studies will

need to investigate the participant's activity level between leaving the laboratory and smoking their next cigarette. There is also a need to investigate in which environment they were exposed to during this time in order to find out whether they were further exposed to smoking cues or stress.

### **7. 2 Recommendations for further research**

In the current investigations, was examined the effects of self-paced walk in cravings, withdrawal symptoms and cue elicited cravings. The reason for using the particular mode and intensity of exercise was that self-paced walking is a more desirable, easily accessible and cost-effective form of exercise. Therefore it has the potential to reach a greater number of smokers, (who are often sedentary and have little confidence about exercising), than any other form of activity. Importantly, the exercise was self-paced, which may add to the external validity of the findings. There is, however, no consensus in literature on how to instruct participants to engage in 'self-paced' or 'preferred intensity' exercise. The present studies attempted to capture the notion of 'self-paced' walking, with some constraints on intensity (i.e., "not out of breath"), over a set distance (one mile and 15 minutes) and pace ("as if walking for a bus or appointment"). The present studies may not have fully captured the notion of self-paced walking but our standardised instructions enable replication in future research. The results of the present studies using exercise in the mode of walking at a self selected intensity compares favourably with the results of previous studies that used forced moderate intensity in the form of indoor cycling (Daniel et al., 2003; Daley et al., 2004;

Daniel et al., 2006; Everson et al., 2006; Pomerleau et al., 1987; Ussher et al., 2006; Ussher et al., 2001). However, so far there is insufficient evidence in the exercise and smoking cessation literature to support a linear or curvilinear relationship between intensity and mode of exercise (i.e. low versus moderate versus high) and effects on cravings (Taylor et al., 2006). The two studies that addressed this issue were poorly designed (Pomerleau et al., 1987; Everson et al., 2006), and no conclusion can be drawn from a comparison across studies involving different exercise intensities (see literature review). Further studies are required to investigate the effects of different durations, modes and intensity of exercise on cravings and withdrawal symptoms. Such evidence is required, as it may help us to understand why exercise is effective, and the optimal levels of exercise.

It was also shown from the present investigations (through ANCOVAs controlling for participant's number of cigarettes smoked daily) that the smoking status of the participants could control the effects of exercise on levels of cravings, withdrawal symptoms and affect. Future studies are needed in order to investigate further the effects of exercise in light and heavy smokers.

The present research has demonstrated that walking is beneficial in reducing cue elicited cravings. Given the recent interest in cue-elicited craving research (Carter & Tiffany, 1999), and the search for therapies to attenuate such responses, there is also scope for further research to compare the effectiveness of exercise against other pharmacological and non-pharmacological strategies used to manage cravings. Given the strong evidence for conventional treatments to aid quit attempts (e.g., nicotine replacement therapy (NRT), and bupropion), the use of exercise should be seen as a supplementary behaviour to aid relapse. Research is needed to investigate how exercise and pharmaceutical aids may interact to effect urges to smoke and promote smoking cessation.

The fact that Study 4 examined smoking initiation after a session of walking in non-abstinent smokers has some important implications. Findings suggest that people who undertook a walk smoked their first cigarette 3.21 hours later than participants who just waited passively. This means that participation in physical activity could have a protective effect against smoking behaviour. This finding is important and means that exercise can be used as an aid for smokers who wish either to quit or cut down on their smoking. However, before one can make generalizations and freely recommend exercise as a proactive aid, there are a number of factors that need to be considered. The physical and psychosocial dimensions of different sports, exercise forms and lifestyle physical activity make it difficult to differentiate the key components of importance for preventing progression to smoking (Taylor and Ussher, 2005). For example Schneider and Greenberg (1992) reported that runners, joggers and fast walkers were less likely to smoke and consume excessive alcohol than team sport participants. The additional pressure associated with competitive sport may result in an increased need for emotional and physical recovery. The relief of such pressures may come from a cigarette in some smokers. In contrast moderate intensity physical activity may provide relaxation and invigorating effects and when people are in a state of calmness and relaxation are more resistant to stressors which might lead them to smoke (Schachter, 1978).

Although biophysical measures were not considered in the present study, one possible explanation for the effects of exercise involves associated increases in dopamine activity. It is generally acknowledged that increases in dopamine within the nucleus accumbens mediate the rewarding effects of nicotine (Koob & Le Moal, 2001). Pharmacological treatments for nicotine addiction (e.g., varenicline) are believed to be effective by reducing the appetite for drug administration (Fagerstrom & Balfour, 2006) and responses to

subsequent nicotine challenge or cue (Carter & Tiffany, 1999). Exercise also has been shown to increase dopamine release into the striatum of the rat (Wilson & Marsden, 1995). In addicted animal studies, exercise appears to engage neurochemical pathways in the brain and also reduce ad libitum use of cocaine (Cosgrove, Hunter, & Carroll, 2002), amphetamine (Kanarek, Marks- Kaufman, D'Anci, & Przypek, 1995), and ethanol (McMillan, McClure, & Hardwick, 1995). A biophysical mechanism may therefore be important in mediating the effects of exercise on cravings. This possibility requires further research.

### **7. 3 Implementing exercise as a smoking cessation aid**

The results of the present studies suggest that a single session of exercise, in laboratory settings, could be recommended as a smoking cessation aid for regulation of cravings, withdrawal symptoms and negative affect. Furthermore, bouts of exercise could also be used as a proactive strategy for reducing cigarette consumption and reducing the risk of progression to nicotine addiction. In order to implement exercise in real smoking cessation settings outside the laboratory there are other issues of importance that need to be addressed.

King et al., (1996) investigated smoking and exercise behaviour in a large sample of smokers, examining the cognitive-behavioural mediators of changing multiple health behaviours. A potential problem of implementing exercise as cessation aid within groups of sedentary smokers is the difficulty inherent in changing both of these behaviours at the same time i.e. stopping smoking whilst at the same time starting regular exercise. King et al., (1996) found that self-efficacy for one behaviour was significantly associated with self-efficacy for the other. Smokers would need to be motivated not only to quit smoking

(Foulds, 1999), but also motivated to increase physical activity. This will be an important issue if exercise is to be implemented as a smoking cessation aid. It may be appropriate to measure intention and attitude of smokers to exercise, as these factors have found to be significant predictors of those who proceed from the contemplation stage of exercise change to the action change (Courneya, Plotnikoff, Hotz, & Birkett, 2001). By doing this it may be possible to determine who will benefit most from exercise interventions.

Using exercise as a smoking cessation aid has also some advantages over other traditional smoking cessation aids for certain groups of smokers. For example pregnant smokers who may be either unable or do not wish to use NRT, exercise may be a viable alternative. Another inhibitor to stop smoking, especially amongst female smokers, is the implications of quitting on weight gain (King et al., 2000). The relative risk of major weight gain in those who quit smoking (as compared with those who continued to smoke) is 8.1 (95 percent confidence interval, 4.4 to 14.9) in men and 5.8 (95 percent confidence interval, 3.7 to 9.1) in women, and it remains high regardless of the duration of cessation (Williamson, Madans, Anda, Kleinman, Giovino, & Byers, 1991).

Although, it was beyond the scope of the present investigation to examine the effects of physical activity on weight management and maintenance, nevertheless one should consider that weight gain is one of the main issues hindering smoking cessation. Therefore, practitioners should prescribe exercise counseling in conjunction with dietary and nutritional advice to promote weight maintenance. Exercise practitioners should advice quitters to use exercise as a coping strategy for elevated cigarette cravings and the associated withdrawal symptoms. Focus on fitness change should not be the purpose of exercise counseling as it might influence motivation and result in lower adherence to the exercise intervention.

Smokers may also have poor health status due to the years of smoking and they are generally considered to be a sedentary population. Therefore, they might have opposed to exercise due to their low fitness level and health status. Special care should be taken when prescribing exercise to this population and exercise advice should be only be provided by trained exercise professionals. Health screening is necessary to be undertaken in order to determine the appropriate level of exercise for each individual. General advice should be given to engage in low-to-moderate exercise, such as brisk walking which may aid coping with cravings and withdrawal symptoms.

## **Chapter 8**

### **8. 0 General Conclusions**

The findings of the present studies suggests that a self paced walk in laboratory settings can be recommended as a smoking cessation aid for regulation of cravings, withdrawal symptoms and negative affect. Exercise could also be effective for regulation of cravings when smoking cues are present or likely to be present. This further supports the efficacy of exercise as an aid to prevent smoking relapse. Bouts of exercise may also be one strategy for reducing cigarette consumption, thereby lowering health risks for those unwilling or unable to quit and reducing the risk of progressing to regular smoking (and other substance misuse). Furthermore, it would appear that the effects of exercise are similar following both brief and longer periods of smoking abstinence and also non abstinence, and for both moderate and higher levels of baseline cravings and withdrawal. A mechanism of the effects of exercise on smoking abstinence may be that exercise could mimic the effects of smoking by inducing feelings of calmness and relaxation. Results of the present investigation suggested that exercise can attenuate levels of cravings by reducing psychological stress and inducing levels of calmness and relaxation. Nevertheless, this thesis provide only a preliminary investigation of the underlying mechanisms of the effects of exercise on smoking outcomes and future studies are warrant to investigate the mechanisms further.

If exercise is to be prescribed as a behavioral intervention to aid smoking cessation, one should also consider the cost effectiveness and safety of exercise versus other conventional



treatments used in smoking cessation, and their implications for the National Health System (NHS). The structured smoking cessation clinics used widely as the most effective intervention in smoking cessation provide social support and improve success rates to around 20% provided that patients use NRT or bupropion – commonly known as Zyban (West 1997). These clinics cost £36.4 million per year. This does not include the cost of NRT or bupropion on prescription (NHS, 2007). The cost of prescription items prescribed in GP practices in England that are dispensed in the community is £9.2 million for NRT, £1.3 million for bupropion (Zyban) - a total of £10.5 million (NHS, 2004). Nevertheless, the use of NRT products and bupropion has adverse side effects and cannot be used by everyone. The most commonly reported side effects of NRT products are headaches, nausea, dizziness, sleep disturbances and skin irritations. Zyban or bupropion on the other hand, an anti-depressant used as an aid to smoking cessation could have more severe side effects. From 550,000 prescriptions (up to 10/02) amongst other side effects such as seizures and psychiatric disorders, 57 deaths have also been reported (Hyder Ferry, L., 2002; BBC news 2002). Nevertheless, even with the support of the smoking cessation aids there are still smokers who are unable to stop smoking completely, whereas others succeed with occasional relapse.

It is worth noting that the magnitude of the reduction in cravings with exercise is encouraging and comparable with, or in many cases exceeding, the acute responses to glucose and oral nicotine replacement therapy (NRT) (West et al, 1999; West et al, 2001). Also, exercise tends to show a more rapid effect on cravings and withdrawal symptoms when compared with studies of oral NRT (West et al., 2001).

## Chapter 8: General Conclusions

Therefore, exercise, such as sessions of brisk walk could be used as an aid to smoking cessation. The advantages of using sessions of brisk walk is that they are cost effective, easily accessible, do not have aversive side effects and they also promote general health and well-being. Walking could be used as an aid, on its own right, to help combat levels of cravings and withdrawal symptoms or it could complement successfully the existent conventional cessation aids. Furthermore, exercise could be used as a relapse prevention strategy for those smokers who have successfully quit but also for people who just wish to cut down on their smoking. In any case the use of exercise as a smoking cessation aid would have positive financial implications to the National Health System (NHS). Nevertheless, this line of research is in its infancy. Further research is needed to determine if exercise is equally effective in natural environments during actual quit attempts.

**Appendices**

**Appendix 1: Medical Questionnaire (PARQ)**

Now I need to ask you a few questions about your general health.  
Could you please answer YES or NO to the following questions.

	YES	NO
1. Has a doctor ever said you have a heart condition and recommended only medically supervised physical activity?		
2. Do you have high or low blood pressure? If you are receiving medication regarding your blood pressure please specify		
3. Have you developed chest pain in the last month?		
4. Do you tend to lose consciousness or fall over as a result of dizziness?		
5. Do you have any bone or joint problems that become aggravated when you are more active.		
7. Are you on Zyban?		
8. Are you on medication? If yes please specify		
9. Are you aware, through your own experience or a doctor's advice, of any other medical reason why you shouldn't be physically active without medical supervision?		

CO Reading ppm : .....

Blood Pressure: .....

Weight: .....

Height : .....

Participants name:..... supervisor's name:.....

Participants signature : ..... supervisor's signature:.....

**Appendix 2: Informed consent for study 1**



**School of Sport and Health Science**

***Acute Effects of Exercise on Smoking Withdrawal***  
**INFORMED CONSENT FORM FOR**

NAME: \_\_\_\_\_

D.O.B: \_\_\_\_\_

DATE: \_\_\_\_\_

TIME: \_\_\_\_\_

**GENERAL**

**1. I confirm that:**

- a) I am willing to take part in the above named experiment as a volunteer subject.
- b) I am not pregnant, not receiving psychiatric treatment, and I have had no significant illness or injury, which may be exaggerated by my participation in the above named experiment.
- c) I have/will inform the person in control of the experiment of any temporary medical condition from which I am suffering or have suffered recently which may be made worse by my participation.

**2. I understand that**

- a) The person in control of the experiment explained to me the nature and purpose of the experiment and informed me of any foreseeable risk to my health as a result of my participation.
- b) I am free to withdraw from my experiment at any time without the need to give a reason.
- c) I agree to terminate any experiment if the person in control feels it is advisable to do so.
- d) Any information collected during the course of the study will be treated as confidential in accordance with the Data Protection Act. The information will be kept for a time up to publication of the data in an academic journal and for a period of 5 years thereafter. At all times my anonymity will be preserved

I agree to take part in this project.

\_\_\_\_\_  
(Signature of participant)

\_\_\_\_\_  
(Date)

This project has been reviewed and approved by the Ethics Committee of the school of Sport and Health Sciences

**Appendix 3: BORG SCALE OF PERCEIVED EXERTION**

- 6**
- 7 Very, Very Light**
- 8**
- 9 Very Light**
- 10**
- 11 Fairly Light**
- 12**
- 13 Somewhat Hard**
- 14**
- 15 Hard**
- 16**
- 17 Very Hard**
- 18**
- 19 Very, Very Hard**
- 20**

Appendices

Appendix 4: Dependence on Smoking (FTND)

These questions help us to understand how dependent you are on smoking.  
Please circle the number that comes closest to your answer.

---

1. How soon after you wake up do you smoke your first cigarette?

- |                    |   |
|--------------------|---|
| Within 5 minutes   | 3 |
| 6-30 minutes       | 2 |
| 30 minutes or more | 1 |

2. Do you find it difficult to stop smoking in no smoking areas?

- |     |   |
|-----|---|
| NO  | 0 |
| YES | 1 |

3. Which cigarette would you most hate to give up?

- |                              |   |
|------------------------------|---|
| The first one in the morning | 1 |
| Another                      | 0 |

4. How many cigarettes a day do you usually smoke?

Please write the number in the box and circle one response below

- |            |   |
|------------|---|
| 10 or less | 0 |
| 11-20      | 1 |
| 21-30      | 2 |
| 31 or more | 3 |

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5. Do you smoke more frequently during the first hours after waking than during the rest of the day?

YES 1

NO 0

6. Do you smoke if you are so ill that you are in bed most of the day?

YES 1

NO 0

7. How much of an urge for a cigarette do you have when:

**Very strong** :1

**Strong** :2

**Somewhat strong** :3

**Either Strong Neither**

**Weak** :4

**Somewhat weak** :5

**Weak** :6

**Very weak** :7

a) When you are faced with a difficult challenge	1	2	3	4	5	6	7
b) When you are annoyed by something	1	2	3	4	5	6	7
c) When you are tense	1	2	3	4	5	6	7
d) When you are angry	1	2	3	4	5	6	7
e) When you are furious	1	2	3	4	5	6	7
f) When you feel irritated	1	2	3	4	5	6	7
g) When you are worried	1	2	3	4	5	6	7
h) You see someone else smoking	1	2	3	4	5	6	7
i) You smell cigarette cigarette smoke	1	2	3	4	5	6	7
g) You see a packet of cigarette	1	2	3	4	5	6	7



Appendix 5: 7 day Physical activity recall questionnaire

WE ARE INTERESTED IN THE AMOUNT OF PHYSICAL ACTIVITY YOU DO

1. I would like you to recall what physical activity you have been doing in the past 7-days.

a) Have you done any vigorous activities? NO \_\_\_\_  
(show activity guide) If YES, complete box

b) Have you done any moderately intensive activities? NO \_\_\_\_  
(show activity guide) If YES, complete box

	DAYS BEFORE TODAY						
	yesterday	2	3	4	5	6	7
moderate	_____	_____	_____	_____	_____	_____	_____
vigorous	_____	_____	_____	_____	_____	_____	_____
	(in minutes)						
Note any specific activities	moderate	_____					
	vigorous	_____					

c) On average, how long have you spent sleeping each day in the last week? \_\_\_\_\_ mins.

2. On average, do you participate in physical activity long enough to work up a sweat at least once a week? NO \_\_\_\_

If YES, how many days per week ? \_\_\_\_ days

3. How much physical activity did you do in the past week relative to the previous month?

Much less	less	about the same	more		much more
1		2	3	4	5

**Vigorous**  
Squash, Running, Football, Swimming, Tennis, Aerobics, Cycling (if out of breath or sweaty); Some occupations that involve frequent climbing, lifting, or carrying heavy loads.

**Moderate**  
Football, Swimming, Tennis, Aerobics, Cycling (if not out of breath or sweaty); Table Tennis, Golf, Social Dancing, Exercises (if out of breath or sweaty); Heavy DIY activities (for example mixing cement), Heavy Gardening (e.g. digging), Heavy Housework (e.g. spring cleaning), Long Walks at a brisk or fast pace, Some occupations that are active but not vigorous.

**Light**  
Table Tennis, Golf, Social Dancing, Exercises (if not out of breath or sweaty); Bowls, Fishing, Darts, Snooker, Lighter Gardening (e.g. weeding), Lighter DIY (e.g. decorating), Long Walks at an average pace, Some occupations that were not entirely sedentary.

## Appendix 6: Questionnaire on smoking urges

*Where*

**1 = Strongly disagree**

**2= disagree**

**3= somewhat disagree**

**4= either agree, neither disagree**

**5= somewhat agree**

**6 = agree**

**7= Strongly agree**

1. Smoking would make me feel very good right now	1	2	3	4	5	6	7
2. I would be less irritable now if I could smoke	1	2	3	4	5	6	7
3. Nothing would be better than smoking a cigarette right now	1	2	3	4	5	6	7
4. I am not missing smoking right now	1	2	3	4	5	6	7
5. I will smoke as soon as I get the chance	1	2	3	4	5	6	7
6. I don't want to smoke now	1	2	3	4	5	6	7
7. Smoking would make me less depressed	1	2	3	4	5	6	7
8. Smoking would not help me calm down now	1	2	3	4	5	6	7
9. If I were offered a cigarette, I would smoke it immediately	1	2	3	4	5	6	7
10. Starting now, I could go without smoking for a long time	1	2	3	4	5	6	7
11. Smoking a cigarette would not be pleasant	1	2	3	4	5	6	7
12. If I were smoking this time, I would feel less bored	1	2	3	4	5	6	7
13. All I want right now is a cigarette	1	2	3	4	5	6	7
14. Smoking right now would make me feel less tired	1	2	3	4	5	6	7
15. Smoking would make me happier now	1	2	3	4	5	6	7
16. Even if it were possible, I probably wouldn't smoke now	1	2	3	4	5	6	7
17. I have no desire for a cigarette right now	1	2	3	4	5	6	7
18. My desire to smoke seems overpowering	1	2	3	4	5	6	7
19. Smoking now would make things just perfect	1	2	3	4	5	6	7
20. I crave a cigarette right now	1	2	3	4	5	6	7

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21. I would not enjoy a cigarette right now	1	2	3	4	5	6	7
22. A cigarette would not taste good right now	1	2	3	4	5	6	7
23. I have an urge for a cigarette	1	2	3	4	5	6	7
24. I could control things better now if I could smoke	1	2	3	4	5	6	7
25. I am going to smoke as soon as possible	1	2	3	4	5	6	7
26. I would not feel better physically if I were smoking	1	2	3	4	5	6	7
27. A cigarette would not be very satisfying now	1	2	3	4	5	6	7
28. If I had a lit cigarette in my hand I probably would not smoke	1	2	3	4	5	6	7
29. If I were smoking now I could think more clearly	1	2	3	4	5	6	7
30. I would do almost everything for a cigarette right now	1	2	3	4	5	6	7
31. I need to smoke now	1	2	3	4	5	6	7
32. Right now, I am not making any plans to smoke	1	2	3	4	5	6	7

## Appendices

### Appendix 7: Feeling Scale (FS)

-5 Very bad

-4

-3 Bad

-2

-1 Fairly Bad

0 Neutral

1 Fairly Good

2

3 Good

4

5 Very Good

## Appendices

### Appendix 8: Felt Arousal Scale (FAS)

1 Low Arousal

2

3

4

5

6 High Arousal

## **Appendix 9: Instructions to RPE, FS and FAS (for the exercise group)**

### **Instructions to rate of Perceived Exertion scale (RPE)**

While you are exercising we want you to try to estimate how hard the work is. We want you to rate the degree of perceived exertion you feel. By perceived exertion we mean the total amount of exertion and physical fatigue. Don't concern yourself with any one factor such as leg pain, shortness of breath, or work grade, but try to concentrate on your total inner feeling of exertion. Try to estimate as honestly and objectively as possible. Don't underestimate the degree of exertion you feel, but don't overestimate it either. Just try to estimate as accurately as possible.

### **Instructions to Feeling Scale (FS)**

While participating in exercise it is quite common to experience changes in mood. Some individuals find exercise enjoyable, whereas others find it to be unpleasant. Additionally, feelings may fluctuate across time. That is, one may feel good and bad a number of times during and after exercise. Each time that you will be asked to refer to the FS please select a number that best represents your true feelings. For example when walking at a level of Perceived Exertion (RPE) of 15 (hard) how would you say you generally feel?

### **Instructions to Felt Arousal Scale (FAS)**

By "arousal" here is meant how "worked up" you feel. You might experience high arousal in one of a variety of ways, for example, as excitement or anxiety or anger. Low arousal might also be experienced by you in one of a number of different ways, for example as relaxation or boredom or calmness.

## **Appendix 10: Instructions to FS and FAS (for the control group)**

### **Instructions to Feeling Scale (FS)**

*During the course of the day it is common to experience changes in mood. Additionally feelings may be fluctuating over time. That is, one may feel good and bad a number of times within the same day. Each time that you will be asked to refer to the FS please select a number that best represents your true feeling.*

### **Instructions to Felt Arousal Scale (FAS)**

*By "arousal" here is meant how "worked up" you feel. You might experience high arousal in one of a variety of ways, for example, as excitement or anxiety or anger. Low arousal might also be experienced by you in one of a number of different ways, for example as relaxation or boredom or calmness.*

**Appendix 11: Informed consent for studies 2,3, and 4**



SCHOOL OF SPORT AND HEALTH SCIENCES

**Acute Effects of Exercise on Smoking Withdrawal**

**INFORMED CONSENT FORM FOR**

NAME: \_\_\_\_\_ D.O.B: \_\_\_\_\_  
DATE: \_\_\_\_\_ TIME: \_\_\_\_\_

GENERAL

**I confirm that:**

- a) I am willing to take part in the above named experiment as a volunteer subject.
- b) I am not pregnant, not receiving psychiatric treatment, and I have had no significant illness or injury, which may be exaggerated by my participation in the above named experiment.
- c) I have/will inform the person in control of the experiment of any temporary medical condition from which I am suffering or have suffered recently which may be made worse by my participation.

**I understand that**

- b) I understand that a part of the experiment will elicit a mild feeling of stress, irritability and anger.
- c) The person in control of the experiment explained to me the nature and purpose of the experiment and informed me of any foreseeable risk to my health as a result of my participation.
- c) I am free to withdraw from my experiment at any time without the need to give a reason.
- d) I agree to terminate any experiment if the person in control feels it is advisable to do so.
- e) Any information collected during the course of the study will be treated as confidential in accordance with the Data Protection act. The experimenter will keep the information for a period of ten years. At all times my anonymity will be preserved
- f) At the end of the study I will get paid £10.00 for my participation.

**"This project has been reviewed and approved by the Ethics Committee  
of the School of Sport and Health Sciences"**

I agree to take part in this project.

(Signature of participant)

(Date)

*This project has been reviewed and approved by the Ethics Committee of the school of  
Sport and Health Sciences*



**Appendix 12: Mood and Physical symptom scale**

This set of questions asks about how you feel right now.

Please show on each of the scales below how you feel right now

	Not at all	Slightly	Somewhat	Very	Extremely
1. Depressed	1	2	3	4	5
2. Irritable	1	2	3	4	5
3. Restless	1	2	3	4	5
4. Tense	1	2	3	4	5
5. Poor concentration	1	2	3	4	5
6. Stressed out	1	2	3	4	5
7. Anxious	1	2	3	4	5

	<i>Strongly disagree</i>	<i>disagree</i>	<i>somewhat disagree</i>	<i>either agree, neither disagree</i>	<i>somewhat agree</i>	<i>agree</i>	<i>Strongly agree</i>
I have a desire for a cigarette right now	1	2	3	4	5	6	7
	<i>Very strong</i>	<i>strong</i>	<i>Somewhat strong</i>	<i>Either Strong Neither weak</i>	<i>Somewhat weak</i>	<i>Weak</i>	<i>Very weak</i>
Strength of desire to smoke right now	1	2	3	4	5	6	7

**Appendix 13: List of Abbreviations and glossary**

min	Minute
sec	Seconds
hr	Hour
m	Meters
cm	Centimetres
ppm	Parts Per Million
kg	Kilograms
$\bar{x}$	Mean
SE	Standard error
SD	Standard deviation
p	Probability; also the success probability of a binomial variable
ns	Non significant
r	Pearson product-moment correlation
$r^2$	Pearson product-moment correlation squared; coefficient of determination
d	Effects size
NRT	Nicotine replacement therapy
NHS	National health system
ACSM	American College of Sport Medicine
BMI	Body mass index
RPE	Rate of perceived exertion
HRR	Heart rate reserve
BP	Blood pressure
SBP	Systolic blood pressure
DBP	Diastolic blood pressure
MAP	Mean arterial pressure
HR	Heart rate
HRR	Heart rate reserve
VO <sub>2</sub> max	maximum amount of oxygen in milliliters
STAI	State-Trait Anxiety Inventory
POMS	Profile of Moods State
PANAS	Positive and Negative Affect Schedule

EFI	Exercise Feeling Inventory
SEES	Subject Exercise Experience Scale
FS	Feeling Scale
FAS	Felt Arousal Scale
MPSS	Mood and physical symptoms scale
FTND	Fagerstrom Test of Nicotine Dependance
QSU	Questionnaire of Smoking Urges

**Glossary:**

***Addiction:*** Addiction is a state in which the body relies on a substance for normal functioning. When this substance is removed, it can cause withdrawal.

***Withdrawal symptoms:*** Withdrawal, also known as withdrawal/abstinence syndrome, refers to the characteristic signs and symptoms that appear when a drug that causes physical dependence is regularly used for a long time and then suddenly discontinued or decreased in dosage. The term can also, less formally, refer to symptoms that appear after discontinuing a drug or other substance (unable to cause true physical dependence) (Wikipedia.com).  
A smoker's nervous system becomes accustomed to functioning with nicotine. When stopping smoking, the reduced nicotine intake will disturb the balance of the central nervous system, causing withdrawal symptoms.  
The most common withdrawal symptoms are: irritation, tension, anger, concentration problems, depression, fatigue, restlessness, stress, anxiety (West, 1998).

***Urges and cravings to smoke:*** Smokers are addicted to the nicotine in cigarettes. Nicotine can create good feelings that make people want to smoke more. But it

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also creates bad feelings when they try to cut back. These negatives feelings generate a strong need and desire to smoke.

Urges link the physical addiction to nicotine to the mental associations that tie all smokers' activities to cigarettes and create a strong feeling to smoke.

Note: In this thesis the terms, Urges and cravings, will be used interchangeably)

### ***Physical activity/ exercise:***

Physical activity is any bodily movement produced by skeletal muscles that results in energy expenditure and it is normally measured in kilocalories (kcal) per unit of time. Types of physical activity are household activities, walking and conditioning activities (i.e. exercise)

### ***Exercise***

A subset of physical activity, is planned structured, repetitive bodily movements that someone engages in for the purpose of improving or maintaining one or more components of physical fitness or health. (Buckworth & Dishman, 2002).

Note: In this thesis the terms Physical activity and exercise will be used interchangeably.

### ***Acute exercise:***

Is a single, relatively short lived bout of exercise (Buckworth & Dishman, 2002)

### ***Chronic exercise:***

Chronic exercise is viewed as acute episodes of exercise repeated at least several times per week for months or years (Morgan, P.,1997).

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